UNIVERSITY OF CALCUTTA

NotificationNo.CSR/13/2023

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.07.2023 approved the Syllabi of the under mentioned subjects for semester wise Four-year (Honours & Honours with Research) / Three-year (Multidisciplinary) programme of U.G. courses of studies, as applicable under CCF,2022 . under this University, as laid down in the accompanying pamphlet.

Name of Subject:

1.Anthropology
2.BBA
3.Bengali
4.BFAD
5.Bio Chemistry
6.Botany
7.Chemistry
8.Commerce
9.Economics
10.Education
11.English
12.Geology
13.Hindi
14.History,Islamic History & Culture
15.Home Science
16.Human Rights
17.Journalism & Mass Communication
18.Mathematics
19.Microbiology (Honours)
20.Molecular Biology
21.Philosophy
22.Physiology
23.Political Science
24.Psychology
25.Social Science
26.Sociology
27.Urdu
28.Women's Studies
29.Zoology

The above shall be effective from the academic session 2023-2024.

12/7/2023

SENATE HOUSE

KOLKATA-700 073

Prof.(Dr.) Debasis Das

Registrar

University of Calcutta

Syllabus for 4-year B.Sc (Honours with or without research) (NEP)

BIOCHEMISTRY (Major & Minor)

2023

Index

UG Biochemistry COURSE STRUCTURE									
	DSC/Core	**Minor**	**IDC/MDC†**	**AEC**	**SEC**	**CVAC**	**SUMMER INTERNSHIP**	**Dissertation/ Research work***	**Total Credits**
SEMESTER	22x4=88	8x4=32	3x3=9	4x2=8	3x4=12	4x2=8	3 credits *	(1x4) + (1x8) =12	172
1	1x4=4 **BCM-H-CC1-1** 3TH+1P	1x4=4 3TH+1P **Minor Paper-1** **BCM-H-CC1-1**	2TH+1P 1x3=3 **BCM-H-IDC1-1 †**	1x2=2	**BCM-H-SEC1-1** 3T+1P 1x4=4	2x2=4	(End of 1st) *		21
2	1x4=4 **BCM-H-CC2-2** 3TH+1P	1x4=4 3TH+1P **Minor Paper-2** **BCM-H-CC2-2**	2TH+1P 1x3=3 **BCM-H-IDC1-2 †**	1x2=2	**BCM-H-SEC2-2** 3T+1P 1x4=4	2x2=4	1x3=3		21
3	2x4=8 **BCM-H-CC3-3** **BCM-H-CC4-3** 2x(3TH+1P)	1x4=4 3TH+1P **Minor Paper-1** **BCM-H-CC1-3**	2TH+1P 1x3=3 **BCM-H-IDC1-3 †**	1x2=2	**BCM-H-SEC3-3** 3T+1P 1x4=4		(End of 3rd) *		21

4	4x4=16 **BCM-H-CC5-4** **BCM-H-CC6-4** **BCM-H-CC7-4** **BCM-H-CC8-4** 4x(3TH+1P)	1x4=4 3TH+1P **Minor Paper-2** **BCM-H-CC2-4**		1x2=2			1x3=3		22
5	4x4=16 **BCM-H-CC9-5** **BCM-H-CC10-5** **BCM-H-CC11-5** **BCM-H-CC12-5** 4x(3TH+1P)	2x4=8 2x(3TH+1P) **Minor Paper-3** **BCM-H-CC3-5**					(End of 5th) *		24
6	3x4=12 **BCM-H-CC13-6** **BCM-H-CC14-6** **BCM-H-CC15-6**	2x4=8 2x(3TH+1P) **Minor Paper-4** **BCM-H-CC8-6**					1x3=3		23

	3x(3TH+1P)								
7	4x4=16 **BCM-H-CC-16-7** **BCM-H-CC-17-7** **BCM-H-CC-18-7** **BCM-H-CC-19-7** 4x(3TH+1P)							1x4=4* **BCM-H-AD-CC1-7** (3TH+1P)	20
8	3x4=12 **BCM-H-CC20-8** **BCM-H-CC21-8** **BCM-H-CC22-8** 3x(3TH+1P)							2x4=8* **BCM-H-AD-CC2-8** (3TH+1P) **BCM-H-AD-CC3-8** (0TH+4TU)	20
Total	21x4=88	8x4=32	3x3=9	4x2=8	3x4=12	4x2=8	1x3=3		172

*** Internship should be done by a student once either before 2nd or 4th or 6th semesters**

† IDC paper (other than major and minor) has to be taken by a student once in 1st to 3rd semesters

Scheme for Biochemistry Major & SEC (TH & P) Curriculum

SEMESTER	DSC Core	Paper Code	Course title	Credit
I	Core Paper 1	BCM-H -CC1-1-TH	Introduction to Biochemistry and Biomolecules	3
	Core Paper 1 Practical	BCM-H -CC1-1-P	Introduction to Biochemistry and Biomolecules	1
	Skill Enhancement course 1	BCM-H-SEC1-1 TH	Tools and Techniques in Biochemistry	3
	Skill Enhancement course 1- Practical	BCM-H-SEC1-1 P	Tools and Techniques in Biochemistry	1
II	Core Paper 2	BCM-H-CC2-2-TH	General and Organic Chemistry	3
	Core Paper 2 Practical	BCM-H-CC2-2-P	General Organic Chemistry	1
	Skill Enhancement course 2	BCM-H-SEC2-2 TH	Protein Purification Techniques	3
	Skill Enhancement course 2 Practical	BCM-H-SEC2-2 P	Protein Purification Techniques	1
III	Core Paper 3	BCM-H-CC3-3-TH	Enzymology	3
	Core Paper 3 Practical	BCM-H-CC3-3-P	Enzymology	1
	Core Paper 4	BCM-H-CC4-3-TH	Metabolism of Carbohydrates and Bioenergetics	3
	Core Paper 4 Practical	BCM-H-CC4-3-P	Metabolism of Carbohydrates	1
	Skill Enhancement course 3	BCM-H-SEC3-3-TH	Clinical Biochemistry	3
	Skill Enhancement course 3- Practical	BCM-H-SEC3-3-P	Clinical Biochemistry	1
IV	Core Paper 5	BCM-H-CC5-4-TH	Physical Chemistry	3
	Core Paper 5 Practical	BCM-H-CC5-4-P	Physical Chemistry	1
	Core Paper 6	BCM-H-CC6-4-TH	Cell Biology and Cell Signaling	3
	Core Paper 6 Practical	BCM-H-CC6-4-P	Cell biology	1
	Core Paper 7	BCM-H-CC7-4-TH	Lipid Metabolism and Membrane biology	3
	Core Paper 7 Practical	BCM-H-CC7-4- P	Lipid Metabolism and Membrane biology	1
	Core Paper 8	BCM-H-CC8-4-TH	Nutritional Biochemistry	3
	Core Paper 8 Practical	BCM-H-CC8-4-P	Nutritional Biochemistry	1
	Core Paper 9	BCM-H-CC9-5-TH	Metabolism of amino acids and	3

			nucleotides	
	Core Paper 9 Practical	BCM-H-CC9-5-P	Metabolism of amino acids and nucleotides	1
	Core Paper 10	BCM-H-CC10-5-TH	Basic Microbiology	3
V	Core Paper 10 Practical	BCM-H-CC10-5-P	Basic Microbiology	1
	Core Paper 11	BCM-H-CC11-5-TH	Human Physiology	3
	Core Paper 11 Practical	BCM-H-CC11-5-P	Human Physiology	1
	Core Paper 12	BCM-H-CC12-5-TH	Gene and Gene Expression	3
	Core Paper 12 Practical	BCM-H-CC12-5-P	Gene and Gene Expression	1
	Core Paper 13	BCM-H-CC13-6-TH	Recombinant DNA technology and Genetic Engineering	3
	Core Paper 13 Practical	BCM-H-CC13-6-P	Recombinant DNA technology	1
VI	Core Paper 14	BCM-H-CC14-6-TH	Immunology	3
	Core Paper 14 Practical	BCM-H-CC14-6-P	Immunology	1
	Core Paper 15	BCM-H-CC15-6-TH	Molecular diagnostics	3
	Core Paper 15 Practical	BCM-H-CC15-6-P	Molecular diagnostics	1
	Core Paper 16	BCM-H-CC16-7-TH	Molecular basis of infectious disease	3
	Core Paper 16 Practical	BCM-H-CC16-7-P	Molecular basis of infectious disease	1
VII	Core Paper 17	BCM-H-CC17-7-TH	Microbial genetics and Biostatistics	3
	Core Paper 17 Practical	BCM-H-CC17-7-P	Microbial genetics	1
	Core Paper 18	BCM-H-CC18-7-TH	Advanced Cell Biology	3
	Core Paper 18 Practical	BCM-H-CC18-7-P	Advanced Cell Biology	1
	Core Paper 19	BCM-H-CC19-7-TH	Advanced Biochemistry	3
	Core Paper 19 Practical	BCM-H-CC19-7-P	Advanced Biochemistry	1
	Core Paper 20	BCM-H-CC20-8-TH	Molecular basis of non-infectious disease	3
	Core Paper 20 Practical	BCM-H-CC20-8-P	Molecular basis of non-infectious disease	1
VIII	Core Paper 21	BCM-H-CC21-8-TH	Regulation of Gene Expression	3
	Core Paper 21 Practical	BCM-H-CC21-8-P	Regulation of Gene Expression	1
	Core Paper 22	BCM-H-CC22-8-TH	Plant Biochemistry	3
	Core Paper 22 Practical	BCM-H-CC22-8-P	Plant Biochemistry	1

Addition Major Papers (VII & VIII Semesters):

SEMESTER	Additional Core Paper	Paper Code	Paper Name	Credits
VII	Additional Core Paper 1	BCM-H-AD-CC1-7TH	Virology	3
	Additional Core Paper 1 Practical	BCM-H-AD-CC1-7P	Virology	1
VIII	Additional Core Paper 2	BCM-H-AD-CC2-8TH	Advanced Techniques in Modern Biology-1	3
	Additional Core Paper 2 Practical/Tu	BCM-H-AD-CC2-8-Tu	Advanced Techniques in Modern Biology-1	1
	Additional Core Paper 3	BCM-H-AD-CC3-8TH	Advanced Techniques in Modern Biology-2	3
	Additional Core Paper 3 Practical/Tu	BCM-H-AD-CC3-8Tu	Advanced Techniques in Modern Biology-2	1

Subject- BIOCHEMISTRY

Discipline Specific courses /Core courses

Detailed Syllabus

SEMESTER 1

Core Paper 1 - Introduction to Biochemistry and Biomolecules (Theory) 3 Credits

(Module 1) Introduction to Biochemistry

Introduction to Biochemistry (Definition, Historical background (Pasteur, Buckner Expt, Crebs discovery, EM), Importance of the study etc.), Scopes and future prospects of Biochemistry in academic as well as industrial aspects (Just mentioning the scope).

Origin of life, types of organisms, prokaryotes, eukaryotes, unicellular, multicellular, compartmentation of functions in lower and higher organisms, endosymbiotic theory and common physiological events of organisms, chemical composition of living organisms, sub-cellular organelles: Structure, function and interrelationship (brief idea).

SI units, mass, volume, temperature, amount, length and time. An overview on the metric system, atomic weight, molecular weight, equivalent weight, basicity of acids, acidity of bases, Avogadro`s number, molarity, normality, molality, Dalton concept, mole concept, concentration, mole to molar conversion, oxidation number and its significance, density and specific gravity, their significances.

(Module 2)- Biomolecules

Unit-I

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 - hemiacetals or hemiketals, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives (N-acetyl-β-D-glucosamine, N-acetylmuramic acid), 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. (Definition, structure, functions, examples only) Carbohydrates as informational molecules, working with carbohydrates (applications of carbohydrate, carbohydrates are significant for energy production, energy source). Brief outline of Glucose utilization and ATP production in human body (only **outline** of digestion, absorption and metabolism i.e. **schemes** of glycolysis, TCA cycle, oxidative phosphorylation, gluconeogenesis, glycogenesis and glycogenolysis).

Introduction to amino acids:

Definition, classification and structures of amino acids, uncommon amino acids (4-hydroxyproline,5-hydroxylysine, gamma carboxyglutamate, selenocysteine-occurrence in proteins). Molecular asymmetry/Chirality of amino acids, Physico-chemical properties of amino acids (amphoteric molecules, ionization, zwitterions, pk values, isoelectric point, Lambert-Beer's law, optical density, absorption spectra), alkali titration of amino acids (alanine, glutamic acid, lysine), Formol titration of glycine (only reaction and principle), reaction of amino acids: ninhydrin and fluorescamine, separation and analysis of amino acids by paper & thin layer chromatography.

Unit-II

Introduction to peptides & proteins:

Peptide bond: Definition, structure and geometry of peptide bond, peptide bond lengths and configuration, dihedral angles, psi and phi helices, beta-sheets and turns, Ramachandran plot (Preliminary Concept**).** Nature of stabilizing bonds in protein– covalent and non-covalent forces. Example of biologically important peptide and its functions in brief (glutathione-peptide of non-protein origin). N-terminal amino acid determination (Edman degradation, dansyl chloride reagent, Sanger's reagent) and C-terminal amino acid determination (carboxypeptidase and using hydrazine), Problems on amino acids sequence in Protein (Trypsin, Chymotrypsin, CNBr).

Proteins: Definition of 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 stabilize structure of proteins. Different types of conjugated proteins (lipoproteins, metalloproteins, glycoprotein, phosphoprotein, hemoprotein, flavoprotein with one example each) Tests for protein (Biuret and Folin-Lowry test).
Biologically important peptides –Biologically important peptides hormones (insulin, oxytocin), antibiotics (penicillin, gramicidin S) and growth factors (EGF, PDGF) (Sources and functions).

Unit-III

Lipids:

Building blocks of lipids – fatty acids, glycerol, ceramide. Storage lipids – triacyl glycerol and waxes. Structural lipids in membranes – Phospholipids, glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipidsas signal molecules (phophatidyl inositols and sphingosine derivatives), cofactors (vitamin E and K) and pigments (conjugated dienes-preliminary ideas only).

Nucleic acids:

Nucleotides – structure and properties. Nucleic acid structure--- Watson-Crick model of DNA. Forms of DNA (A, B and Z DNA), Structure and function of major species of RNA – mRNA, tRNA and rRNA. Basic concept of central dogma (**Schemes** of Replication, transcription and translation), Nucleic acid chemistry – DNA UV absorption, effect of acid and alkali on DNA and RNA. DNA melting, T_m value of DNA, hyperchromic shift of A_{260} of dsDNA during denaturation. Other functions of nucleotides – source of energy (nucleoside triphosphates), component of coenzymes (FAD, NAD^+), second messengers (cAMP, cGMP).

Reference books:

- 1.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.
- 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. Harper's Illustrated Biochemistry (27th edition), ISBN-13:978-0071253017
- 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
- 5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin,
- T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

Core Paper 1P-Biomolecules (Practical) 1 Credit

List of Practical

1. Separation of amino acids by thin layer chromatography.
2. Qualitative test for carbohydrate.
3. Qualitative test for lipid.
4. Qualitative test for amino acids & proteins.
5. Assay of proteins using Lowry method, standard curve preparation.

SEMESTER 2

Core Paper 2-General and Organic Chemistry (Theory) 3 Credits

(Module 1)- General Chemistry

Atomic Structure (briefly)

Concept of atomic orbital, shapes of s, p and d orbitals, radial and angular probability of s, p and dorbitals (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).

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'srule;Conceptofresonance,resonanceenergy,resonancestructures,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 4and 6. Determination of configuration of cis-, trans- isomers by chemical methods.

Radioactivity and the applications of radioactive isotopes

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

ReferenceBooks

1. General &Inorganic Chemistry-R.P.Sarkar
2. Inorganic Chemistry-R.L.Dutta
3. New Concise Inorganic Chemistry -J.D.Lee
4. Inorganic Chemistry, PrinciplesofStructureandReactivity-J.E.Huheey,E.A.Keiter,&R.L.Keiter
5. Fundamental Concepts of inorganic Chemistry–A.K.Das

(Module 2)- General Organic Chemistry

Unit-I

Basic Concept of Organic Chemistry (GOC):

Concept of hybridisation, inductive effect, resonance, hyperconjugation, Steric Effect, dipole moment, bond distance, and 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).

Aromaticity: Huckel's rules for aromaticity, antiaromaticity, nonaromaticity & homoaromaticity.

Typeofreactions: Ionic, radical and pericyclic (conceptonly) reactions; Type of bond cleavage: heterolytic and, homolytic bond cleavage; Type of reagents: electrophile and nucleophile. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate.

Stereochemistry of Carbon Compounds:

Stereochemistry Optical activity of chiral compounds: specific rotation, measurement of specific rotationby polarimeter, racemisation (general principle) resolution of simple acids and bases. Representation of molecules in sawhorse, Fischer, flying wedge and Newman formulae and their intertranslations, Configuration: i) systems involving 1, 2, 3 stereocentres, 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. Conformation: 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-II

General treatment of Reaction mechanism and kinetic study:

Reaction kinetics: transition state theory, rate constant and free energy of activation, free energy profiles for one step and two step reactions (concept only).

Nucleophilic substitution reactions: Substitutionr eactions involving S_N1, $S_N2$and S_Ni mechanisms. Effect of substrate structure, nucleophiles (including ambident nucleophiles), solvent and leaving group; substitution involving neighboring group participations (NGP).

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

Aromatic Electrophilic and Nucleophilic substitution: Electrophilic substitution eactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions) and activated nucleophilic substitution reactions.

Addition reactions to multiple bonds and carbonyl groups: Addition reactions to Carbon–carbon multiplebonds-Electrophilic additions mechanisms (conceptonly), dihydoxylation(1,2-diol), ozonolysis. Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$; oxidation of alcohols with PCC; oxidation of1,2-diols using periodic acid and lead tetraacetate. Formation of acetal/ketal, Cannizzaro (includingcross-Cannizzaro), aldol condensation (including directed and cross-aldol condensation**)**.

Organo-metallics and Heterocycles:

Organometallic chemistry:Grignard reactions (including abnormal behavior) and Corey-Houses ynthesis (Gilman Catalyst,R_2CuLi).

Heterocycles: Structural aspects of five and six membered heterocycles containing heteroatoms (pyrrole, furan, thiophene and pyridine). Reactivity towards electrophilic and nucleophilic substitution (Concept only).

ReferenceBooks

1. OrganicChemistry(vol.1&2)-I.L.Finar
2. AGuidetoOrganic ReactionMechanism -P.Sykes
3. OrganicChemistry-P.Wothers,N.Greeves, J.Clayden,&S.Warren
4. OrganicChemistry-G.M.Loudon

5. StereochemistryofCarbonCompounds -D.Nasipuri
6. BasicStereochemistryofOrganicCompounds -S.Sengupta
7. StereochemistryofOrganicCompounds-E.L.Eliel,&S.H.Wilen

Core Paper 2 P- General Organic Chemistry (Practical) 1 Credit

I. Physical characteristics (colour, odour, texture)
II. Solubility and classification(Solvents: H_2O,5%HCl,5% $NaHCO_3$,5%NaOH)
III. Detection of special elements (N, Cl, S) by Lassaigne's tests.
IV. Detection of the following functional groups by systematic chemical tests: (aromatic amino (– NH_2),aromatic nitro (– NO_2), Amido (–$CONH_2$, including imide), 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.**

LABORATORYRECORDS

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.

PracticalReferenceBooks:

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

SEMESTER 3

Core Paper 3- ENZYMOLOGY (Theory) 3 credits

UNIT I

Enzyme and Enzyme Catalysis

a. Definition of enzymes, Nature of enzymes, protein and non-protein (ribozyme), apoenzyme and holoenzyme, differences between biocatalysts and chemical catalysts.

b. Cofactors: metal ions (Zn^{+2}, Mg^{+2}, Fe^{2+}) [one example of enzyme using metal ion with reaction], coenzymes, (NAD+, NADP+, HSCoA, FH4, cobalamin), prosthetic groups (FAD, TPP, PALPO, biotin) [structures not needed, vitamin precursors, two examples of enzymes for each with reactions showing proper equation] , co-substrate (NAD+)- one example with reaction.

c. IUBMB Classification of enzymes, Name & two examples of each class with reaction

d. Concept of active site, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis. proximity and orientation effect (orbital steering hypothesis to be mentioned), strain and distortion theory (example of Lysozyme/RNase catalyzed reaction).

e. Catalytic power and specificity of enzymes (stereospecifity and geometric specificity)

f. Mechanism of enzyme catalysis (basic concepts)
   i) acid- base catalysis (example- RNase A)
   ii) Metal ion catalysis: Metal activated enzymes (e.g., hexokinase) and metalloenzymes (e.g., carbonic anhydrase)
   iii) covalent catalysis (example- chymotrypsin)

UNIT II

Enzyme kinetics

a. Parameters for spontaneous chemical reactions (Concept of ΔG, $\Delta H, \Delta S$, Keq), concept of Activation Energy, energy profile diagram for uncatalyzed and enzyme-catalyzed reactions, Definition of Transition state, rate-determining step of a reaction, multistep reactions with energy profile diagram, binding energy, transition state analogs.

b. Concepts of rate, rate constant and order of a reaction (first order reaction- derivation not needed, rate equation and graph needed), half-life period and its significance.

c. Concept of pre steady state and steady state, initial rate, maximum velocity (Vmax), Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions, association and dissociation constant, Michaelis-Menten equation (derivation and graphical representation), Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. Km and Vmax, Kcat and turnover number, Kcat/Km, enzyme activity, specific activity, katal, International Unit of enzyme activity. Numerical problems on Enzyme kinetics.

d. Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, time, metal ions on the activity of enzyme (Cu^{2+}, As^{2+}, Hg^{2+}, Pb^{2+}: one example of each).

e. Bisubstrate reactions: Sequential reactions (Ordered and Random reactions with definition and example), Ping-pong reactions (definition and example of transamination reactions), differences between sequential and ping-pong reactions.

UNIT III

Enzyme Inhibition and Regulation of Enzyme Activity

a. Reversible inhibition (competitive, uncompetitive, non-competitive, mixed – one example of each, Michaelis-Menten equation in the presence of respective inhibitor and effect of each inhibitor on K_M and V_{max} values.)

b. Irreversible inhibition- Mechanism based inhibitors (suicide substrate or suicide inhibitor), example of an antibiotic that acts as an inhibitor (Penicillin)

c. Control of activities of single enzymes: feedback inhibition

d. Properties of Allosteric enzyme (Aspartate transcarbamoylase) and its regulation, definition of M and K enzymes, Sequential and Symmetry Model.

e. Reversible covalent modification: phosphorylation and dephosphorylation (glycogen phosphorylase and glycogen synthase).

f. Proteolytic cleavage- zymogen (chymotrypsinogen and trypsinogen).

g. Isoenzymes - properties and physiological and clinical significance (lactate dehydrogenase and creatine kinase).

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 AsiaPvt.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 Paper 3P- ENZYMOLOGY (PRACTICAL) 1 credit

List of Practical

- Standard curve of p-nitrophenol.
- Assay of enzyme activity and specific activity of Alkanine Phosphatase.
- Effect of pH on the enzyme activity.
- Effect of temperature on the enzyme activity.
- Determination of Km and Vmax using Lineweaver-Burk graph.
- Enzyme inhibition - calculation of Ki for competitive inhibition.

Core Paper 4- Metabolism of Carbohydrates and Bioenergetics (Theory) 3 Credits

UNIT I

Metabolism of Carbohydrates

Basic design of metabolism

Autotrophs and heterotrophs, Metabolic pathways, catabolism and 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 and role of the enzymes involved, net number of ATP molecules formed, fates of pyruvate, fermentation (homolactic and alcoholic), substrate cycling (one example), feeder pathways for glycolysis (fructose, mannose, galactose), galactosemia. Synthesis of glucose from non-carbohydrate sources, Steps in Gluconeogenesis(not exact reversal of glycolysis), role of the enzymes: Pyruvate Carboxylase and PEPCK, Glucose-6-phosphatase, Fructose bisphosphatase, Reciprocal regulation of glycolysis and gluconeogenesis

Pentose phosphate pathway: pathway, role of enzymes, significance, control of the pathway and Glucose-6-phosphate dehydrogenase deficiency.Glycogenesis and glycogenolysis : pathways, regulation of glycogen metabolism, glycogen storage diseases.

Citric acid cycle

Production of acetyl CoA (Role of PDC: steps and reactions), Reactions of citric acid cycle : role of enzymes and net ATP count, Amphibolic nature of TCA cycle, Regulation of citric acid cycle, Glyoxylate cycle.

UNIT II

Bioenergetics

Introduction to bioenergetics

ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Universal electron carriers.

Oxidative phosphorylation

Mitochondria: Anatomy, Electron transport chain - its organization and function. Metabolite transporters in mitochondria, Inhibitors of ETC and P/O ratio: experimental layouts.Peter Mitchell's chemiosmotic hypothesis. Proton motive force ATP synthase: structure and mechanism of ATP synthesis. Uncouplers and mechanism of hormonally induced uncoupling (Thermogenesis)Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms.

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

Core Paper 4P- Metabolism of Carbohydrates and Bioenergetics (PRACTICAL)
1 credit

List of Practical

1. Estimation of blood plasma glucose by GOD-POD method.
2. Estimation of glycosylated hemoglobin (Demonstration)
3. Estimation of serum amylase activity by kinetic method
4. Estimation of serum creatinine

SEMESTER 4

Core Paper 5- Physical Chemistry (Theory) 3 Credits

Unit-I
Principles of Thermodynamics

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.
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.
Concept of thermochemistry, laws of thermochemistry, Kirchhoff's equation, Change in enthalpy in different reactions.
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.
Clausius inequality, condition of reversibility and irreversibility of a process, auxiliary state function-Helmholtz free energy and Gibbs free energy and their simple applications.

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), preliminary idea of chemical equilibrium, equilibrium constants, Le Chatelier's principle and its simple applications.
Homogeneous equilibrium: Use of different standard states to define Kp, Kc, Kx and their interrelations, examples of homogenous equilibrium.
Ionic equilibrium in solution:
Hydrolysis of weak acids and bases, pKa, pKb, pH, pOH, acid-base neutralization curves, concept of a buffer, buffer action definition, Henderson-Hasselbalch equation and preparation of buffers, buffer capacity, Good's buffers. Buffers used in living system.
Colloidal State: Types and properties of colloids, electrokinetic phenomena, concept of Zeta potential, stability of colloids, mechanism of coagulation, Brownian motion, Gibbs adsorption isotherm (statement and significance), surfactant, micelle formation, critical packing parameter.

Unit-III

Electrochemistry

Flow of electrical charge, electrical conductance, cell constant, specific conductance and equivalent conductance, variation of equivalent conductance of strong and weak electrolytes with dilution,

Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility, equivalent conductance at infinite dilution for weak electrolytes and determination of dissociation constants of weak electrolytes from conductance measurements, conductometric titrations.
Basic concepts of electrochemical cell and cell reactions, EMF of cell, Nernst equation, its use in measuring thermodynamic properties (brief introduction) types of electrodes, glass electrode, determination of pH of a solution, working of a pH meter. Concepts of activity and activity coefficient with special reference to electrolyte solutions, statement of Debye-Huckel limiting law and its applications.

Core Paper 5P- Physical Chemistry (Practical) 1 Credit

1. Determination of specific rotation of a given optically active compound and percentage composition of its aqueous solution using polarimeter
2. Formol titration (acidic, basic, neutral aminoacid).
3. Conductometric titration: weak acid vs strong base.

Reference Books:

- Physical Chemistry-P. C.Rakshit
- Lehninger Principles of Biochemistry-Nelson &Cox
- Text Book of Physical Chemistry-K. L.Kapoor
- Physical Chemistry-HrishikeshChatterjee

Core Paper 6- Cell biology and cell signaling (Theory) 3 Credits

Unit-I

Introduction to cell biology: Prokaryotic (Archaea and Eubacteria) and eukaryotic cell (Animal and Plant cells), Cells as experimental models.

Structure and functions of different cell organelles: Schematic diagram & brief functions of eukaryotic cell structure, cell membrane (membrane composition, fluid mosaic model& its validity). Nucleus, Structure of nuclear envelope, nuclear pore complex, ER structure, Organization of Golgi apparatus, 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).

Unit-II

Cell wall and extracellular matrix:

Prokaryotic cell wall and Cell wall inPlant, cell matrix proteins (concept & examples). Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata. (Schematically representation and fundamental ideas). Cell-Cell Interactions and Cell-Matrix Interactions; Components of Extracellular Matrix: Collagen and Non-Collagen Components.

Unit-III

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 (Schematic explanation)

Cell cycle: Definition and phases of Eukaryotic cell cycle, importance of cell cycle restriction pointand checkpoints. Cell division- a basic understanding of mitosis and meiosis (Schematic description).

Cell signalling (Preliminary concept)

Fundamental theme of a generalized cell signalling pathway (Schematic description), Classification of cell signalling components) Receptors-extracellular and intracellular. G protein coupled receptors, G proteins, Role of second messengers in signalling cascade- cAMP, cGMP, IP3, DAG, Ca2+, NO.Signal transduction (Flow diagram) and importance of signal attenuation, Effector systems- adenyl cyclase, guanyl cyclase, PDE, PLC. Regulation of cell signalling by phosphorylation and dephosphorylation (Concept only)

Core Paper 6P- Cell Biology (Practical) 1 Credit

List of Practical

1. Visualization of animal (Squamous epithelium) and plant (Onion) cells by methylene blue.

2. Micrographs of different cell components

3. Study of mitosis and meiosis from permanent slides (dry lab).

Reference Books:

- Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6 edition. John Wiley & Sons. Inc.
- Alberts, B., Johnson,A., Lewis, J., and Enlarge, M. 2008 Molecular Biology of the Cell. 5th ed., Garland Science (Princeton),
- Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J. 2012. Molecular Cell Biology. 7th ed., W.H. Freeman & Company (New York),
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
- 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 Biochemistry (2011) 4th ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

Core Paper 7- Lipid metabolism and Membrane biology (Theory) 3 credits

Unit I

Fatty acid oxidation

Fatty acid activation, fatty acid transport to mitochondria, β-oxidation of saturated, unsaturated, odd chain and even chain fatty acids, regulation of fatty acid oxidation,
peroxisomal β-oxidation, differences with mitochondrial β-oxidation, α-oxidation,
ω-oxidation, metabolism of ketone bodies, ketoacidosis and ketosis.

Fatty acid biosynthesis

Rare-determining step in fatty acid synthesis, Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids, fatty acid elongation, desaturation, regulation of fatty acid synthesis.

Triacylglycerols, Eicosanoids, steroids and isoprenoids

Biosynthesis and physiological importance of triacylglycerol (Triacylglycerol cycle). Precursor and physiological importance of prostagladins, leukotrienes and thromboxanes. Rate-determining step in cholesterol biosynthesis and regulation of cholesterol biosynthesis. Precursor and physiological importance of isoprenoids.

Lipid storage diseases- G_{M1}Gangliosidosis, Tay–Sachs disease, Gaucher's disease, Niemann–Pick disease, Fabry's disease (Enzyme Deficiency, principal storage substance, major symptoms)

Unit II

Introduction to biomembranes

Composition of bio membranes - prokaryotic, eukaryotic, neuronal and subcellular membranes. Study of membrane proteins and their significance (lipid-anchored, integral, peripheral and auxiliary membrane protein), Fluid mosaic model with experimental proof. Monolayer, planer bilayer and liposomes as model membrane systems.

Membrane structures and dynamics (Preliminary concept only)

Polymorphic structures of amphiphilic molecules in aqueous solutions – micelles and bilayers. CMC, critical packing parameter. Membrane asymmetry. Precursor, and physiological importance of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, Precursor and physiological importance of plasmalogens, sphingolipids and glycolipids, Membrane skeleton, lipid rafts, 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, Hydropathy plot (Concept only).

Membrane transport (Definition & concept only)

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 (Preliminary concept only)- 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.

Core Paper 7P - Lipid metabolism and Membrane biology (Practical) 1 Credit

List of Practical

1. Estimation of serum cholesterol by CHOD-PAP method
2. Determination of CMC of detergents by conductometer
3. RBC ghost cell preparation.
4. Determination of phosphate from crude phospholipid (Lecithin/Cephalin)[Demo only]

Reference Books

- 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
- 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.

Core Paper 8 – Nutritional Biochemistry (Theory) 3 Credits

Unit-I
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 (RDA) for different age groups.

Dietary carbohydrates, lipids, proteins and health

RDA, sources and functions and storage of carbohydrates, proteins and lipids in human health, essential and non-essential amino acids and fatty acids, excess, toxicity, imbalance and deficiency of amino acids and fatty acids, dietary importance/implications of MUFA, PUFA, SFA, omega fatty acids with omega3/omega 6 ratio, phospholipids, cholesterol, triglycerides, saturated fats and oils, combined ratios of n6 and n3, lipotropic factors, amino acid supplementation, amino acid pool, amino acid availability, antagonism, NPU, BV, nitrogen balance, nitrogen cycle, protein calorie malnutrition - Kwashiorkar and Marasmus.

Dietary fibres and health

Role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Unit-II

Vitamins

RDA, sources, storage, adsorption, distribution, metabolism and excretion (ADME) of fat- and water-soluble vitamins, functional role of vitamins (vitamin A as an antioxidant, in visual cycle, dermatology and immunity, vitamin B6 in pyridoxal phosphate formation, niacin-metabolic interrelation between tryptophan, niacin and NAD/ NADP, vitamin C as cofactor in amino acid modifications, extra-skeletal role of Vitamin D and its effect on bone physiology, vitamin E as an antioxidant, vitamin K in gamma carboxylation and blood coagulation, hypervitaminosis and deficiency of vitamins with deficiency symptoms and treatment. A correlation of Vitamin B12 and folate mentioning dietary source, RDA, absorption, metabolic role and biochemical basis for deficiency symptoms.

Minerals

RDA, sources, storage, digestion, absorption, utilization, transport, excretion, balance, deficiency and distribution in human body for calcium, phosphorus, iron, iodine, fluoride, Mg, Cu, Zn, Se, manganese,

chromium, molybdenum, calcium: phosphorus ratio, role of iron in prevention of anemia, iodine cycle, toxicity of minerals with special reference to arsenic.

Unit-III

Assessment of Nutritional status

BMI, biochemical assessment, basal and comprehensive metabolic panel, CBC, urine analyses, assessment of anemia, ROS assessment, GTT and glycosylated Hb, differential diagnosis of B12 and folate.

Food and drug interactions and Nutraceuticals

Definition and functional importance of nutriceuticals, interactive effects of alcohol, tobacco, anti-depressants and psychoactive drugs on (1) nutrient metabolism and assimilation, (2) appetite changes, (3) nutrient deficiency and malnutrition.

Core Paper-8P- Nutritional Biochemistry (Practical) 1 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.

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
- Nutrition Science by B. Sri Lakshmi New Age International (P) Limited, Publishers

SEMESTER 5

Paper 9- Metabolism of Amino acids and Nucleotides (Theory) 3 credits

UNIT I

Amino acid Metabolism:

Transamination: [Reaction (Mechanism not needed) Role of pyridoxal phosphate, glucose-alanine cycle.], Oxidative deamination [reaction, role of enzyme, regulation, related disorder], Other deamination reactions (Amino acid oxidases), Urea cycle and inherited defects of urea cycle, Kreb's bicycle. Glucogenic and ketogenic amino acids. Amino acid decarboxylation: Glu, Trp, His, Tyr. Precursor functions of amino acids, Creatine, polyamines (putresine, spermine, spermidine), Catabolism of amino acids Phe, Glu, Gly. Disorders of amino acids metabolism: phenylketonuria, alkaptonuria, albinism. Biosynthesis of amino acids: Gly Glu, Gln, Regulation of enzyme: Glutamine synthetase

Porphyrin Metabolism:

Heme Biosynthesis, Heme Catabolism, Disorders related to heme metabolism: Porphyrias, Jaundice.

UNIT II

Nucleotide Metabolism:

Denovo biosynthesis of purine and pyrimidine nucleotides and regulation, Salvage pathways: reactions and enzymes involved.c. Precursor of deoxyribonucleotides: role of Ribonucleotide, reductase and its regulation.Coenzyme nucleotides: Precursor only.Degradation of purine and pyrimidine nucleotides, Biosynthesis of Thymine (concept of suicide inhibition.)Antifolates : anticancer agents.Disorders of purine and pyrimidine metabolism –Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency, orotic aciduria.Metabolism of one carbon units.

Integration of metabolism

Integration of 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.
- 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., CengageLearning (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

Core Paper 9P-Metabolism of Amino Acids and Nucleotides (Practical)
1 credit

1. Assay of serum transaminases – SGOT and SGPT.

2. Estimation of total protein and albumin in serum.

3. Estimation of serum uric acid.

Core Paper-10- Basic Microbiology (Theory) 3 Credits

Unit-I

Introduction: Basic Concepts of Microbiology. Evolution of micro-organisms-Millers' Experiment, 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: Definition of auxochrome; Chromophores; Acidic and Basic dyes; Mordant; Classification of stains; Simple and differential staining: theories of staining, Gram staining; acid fast staining; endospore staining; mechanism of gram staining

Morphology and subcellular structures: Size and shape of bacteria (examples of Bacillus, Coccus, Spirillum); Bacterial cell wall structure, Slime layer, Mycelial morphology: Actinomycetes, Capsule, 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). Concept of Ribotyping.

Unit-II

Microbial Nutrition: Nutritional types (definition and example) - Photoautotrophs, Photo-organotrophs, Chemolithotrophs (ammonia, nitrite, sulfur, hydrogen, iron oxidizing bacteria); Chemoorganotrophs

Bacterial Growth and its regulation: Growth phases - Generation time. Kinetics of growth, Batch culture. Continuous culture. Synchronous culture (definition and brief description). Bacteriological media: nutrient broth (liquid media) and nutrient agar (solid media), complex media and synthetic media (mention only). Techniques of pure culture. Physical Factors influencing bacterial growth: pH, temperature, oxygen, osmotic pressure, salt concentration, water activity.

Basic Principle of storage of bacteria: idea of slant, stab cultures, short- and long-term storage of bacteria.

Unit-III

Control of micro-organisms: 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. Basic concept of probiotic therapy.

Core Paper 10P - Basic Microbiology (Practical) 1 Credit

List of Practical

1. Basic Microbiological Laboratory Practices and Biosafety.

2. 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 (both broth and solid media).

4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent

slides/ pictographs

5. Gram staining

6. Isolation of pure cultures of bacteria: Streaking method, Spread plate technique and Pour plate method.

Reference Books:

- Stanier, RY., et al., General Microbiology, 5th ed. Macmillan Press.
- Pelczar. M., et al., Microbiology, 5th ed.,2000, Tata-McGraw Hill
- Atlas, RM., Principles of Microbiology, 2nd ed.,1997, McGraw-Hill
- Salle, AJ., Fundamental Principles of Bacteriology, 7th ed.,1999, Tata- McGraw Hill
- Prescott, LM., Microbiology, 6th ed. 2005, McGraw-Hill.

Core Paper 11- Human Physiology (Theory) 3 Credits

Unit-I

Circulatory system
Definition and composition of intracellular, extracellular and interstitial fluids, lymph, components of blood (plasma & formed elements, serum proteins), cascade and factors controlling blood coagulation, anticoagulants, definition of homeostasis and types & factors controlling homeostasis, causes and types of anemia, polycythemia, haemophilia, thrombosis and fibrinolysis.

Cardiovascular system
Basic structure of heart, heart valves and cardiac circulation, cardiac conduction system and electrocardiogram, cardiac cycle, cardiac output, cardiovascular diseases (CAD, MI, cardiac arrest, heart failure).

Respiratory system
Basic structure of respiratory organs, mechanism of breathing, respiratory volumes and capacities, exchange and transport of oxygen and carbon di oxide, control of respiration, pulmonary circulation, disorders of respiratory system (COPD, emphysema, bronchitis, asthma)

Digestive system
Basic structure of GI tract and accessory digestive organs, mechanisms of digestion and absorption of carbohydrates, protein, lipids in different parts of GI tract, hepatic circulation.

Excretory system
Basic structure of kidneys, blood supply of kidneys, nephrons, urine formation (GF, GFR, regulation of GFR, tubular reabsorption and secretion), role of kidney in acid-base balance (acidosis, alkalosis) and water-electrolyte balance, renin-angiotensin mechanism.

Nervous system
Basic structure of neurons, synapses, synthesis and functions of excitatory and inhibitory neurotransmitters (Glutamic acid, GABA, dopamine, serotonin, acetylcholine), neurotransmitter-receptor binding, IPSP, EPSP, action potentials, neurodegenerative diseases (Parkinson's, Alzheimer's, Schizophrenia, Dementia).

Unit-II

Introduction to endocrinology
Definition of endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms, classification of hormones, circulation, transport, clearance and half-lives of hormones.

Biochemical synthesis and physiological functions of hormones
Hypothalamus (RH), anterior pituitary (TSH, LH, FSH, POMC, GH, PRL), posterior pituitary (oxytocin, vasopressin/ADH), pineal (melatonin), thyroid (T3, T4, calcitonin), parathyroid (PTH), adrenal (glucocorticoids, mineralocorticoids/aldosterone, epinephrin/adrenalin, nor-epinephrin/nor-adrenalin)

glands, GI tract (insulin, glucagon, gastrin, secretin, CCK, GIP, adiponectin, leptin and ghrelin) and gonads (androgen, testosterone, progesterone, estrogen).

Secondary endocrine organs
Liver, kidney, heart (definition of secondary endocrine organs, biochemical functions of the hormones secreted from these organs)

Regulation of endocrine secretion
Feedback cycle and hypothalamic-pituitary axes.

Endocrine disorders
Hypo- and hyper-functioning of endocrine organs with mention to gigantism, acromegaly, dwarfism, pigmies, diabetes mellitus, diabetes insipidus, iodine-deficiency goitre, Hashimoto's disease, thyroiditis, Grave's disease/exophthalmic goitre, Addison's disease, Cushing's syndrome, prolactinoma. Introduction to HRT as a therapy.

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). 42 ISBN: 978-0-87893- 300-6.
- Human Physiology by C. C. Chatterjee
- Biochemistry by Debajyoti Das
- Medical Physiology by Guyton and Hall
- Review of Medical Physiology by W.F. Ganong
- An Illustrated Biochemistry by Herper
- BiochemistrybyVoet&Voet
- Biochemistry by L. Stryer

Core Paper 11P- Human Physiology Practical 1 Credit

List of Practical

1. Quantitative estimation of haemoglobin from blood

2. Estimation of serum proteins and determination of ratio of albumin and globulin

3. Estimation of normal and abnormal constituents of urine

4. Estimation of serum phosphorus and calcium

Core Paper 12- Gene and Gene Expression (Theory) 3 credits

Unit-I

Structure of DNA
DNA structure, features of the double helix, various forms of DNA, denaturation and renaturation of DNA.

Genes and genomic organization
Definition of a gene, organization of genes in viruses, bacteria, eukaryotes. DNA Supercoiling (Linking Number, Twist number, Writhe number), DNA Topoisomerase role in supercoiling, 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, Meselson and Stahl experiment, stages of replication of E. coli chromosome, Rolling circle replication (Concept only), 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, silent, nonsense, leaky mutation, missense, 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.

Unit-II

Biosynthesis of RNA in prokaryotes
Bacterial 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.
Concept of Central Dogma, One gene–one polypeptide hypothesis by Beadle and Tatum.

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.

Mendel's principles & chromosomal basis of heredity and Extensions of Mendelism Genetics:
Basic principles of Mendelian genetics (monohybrid and dihybrid, test and back crosses).

Core Paper 12P- Gene, Gene Expression and Regulation (Practical) 1 Credit

1. Preparation of culture medium (LB) for *E.coli* (both solid and liquid) and raise culture of *E.coli.*

2. Extraction of total nucleic acids (genomic DNA) from bacterial cells and quantitative estimation of DNA using spectrophotometer (A260 measurement) and assessment of purity (A260/A280). Agarose gel electrophoresis.

3. Concept of standard curve and estimation of unknown DNA concentration.

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 SivaramaSastri, 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.

SEMESTER 6

Core Paper 13- Recombinant DNA technology and Genetic Engineering (Theory) 3 Credits

Unit-I

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 (Concept of primers), 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, northern, western and southwestern blot; 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.

Unit-II

Polymerase chain reaction

Fundamentals of polymerase chain reaction, designing primers for PCR. Studying PCR products. Cloning PCR products, Reverse transcription PCR, Quantitative Real time PCR (Principle), Diagnostic use of PCR.

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.

DNA sequencing

DNA sequencing by Sanger's method, modifications based on Sanger's method. Automated DNA sequencing. Next generation sequencing- Pyrosequencing and illumina Sequencing (Concept only), RNA Sequencing (Brief concept only).

Applications of genetic engineering in Biotechnology

Applications in medicine, production of recombinant pharmaceuticals such as insulin. Recombinant vaccines (HBsAg), Gene therapy (brief concept). Applications in agriculture - plant genetic engineering, herbicide resistant crops (Glyphosate-tolerant crops), virus and insect resistant crops (Schematic demonstration), problems with genetically modified plants, safety concerns.

Core Paper 13P- Recombinant DNA Technology and Genetic Engineering (Practical) 1 Credit

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. Primer designing (in silico) using any one webtool

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 Paper 14- Immunology (Theory) 3 Credits

Unit-I

Cells and organs of the immune system

Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT). Mononuclear cells, Granulocytic cells, Mast cells, Dendritic cells- brief characteristics and functions.

Innate and adaptive immunity

Innate immunity- definition, characteristics, components, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), cell types of adaptive immunity, characteristics of adaptive immunity, connections between innate and adaptive immunity, cell adhesion molecules, Cytokines (definition, examples and functions)

Antigens

Chemical nature, antigenicity, immunogenicity, hapten, epitopes, Adjuvant (definition, examples, function), B and T cell epitopes.

Immunoglobulins

Isotypes- definition, basic and fine structures, general characteristics and functions; effector functions of antibody, antigenic determinants on Ig and Ig super family, Monoclonal (basic procedure of synthesis) and polyclonal antibody (definition and characteristics)

Unit-II

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).

Antigen-antibody interaction

Precipitation reactions-Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition.

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 systems

Three pathways of complement activation and their biological consequences.

Unit-III

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.

Vaccines

Active and passive immunization (definition, brief characteristics, examples and functions); Attenuated and inactivated viral or bacterial vaccines (definition, brief characteristics, functions, examples)

Core Paper 14P- Immunology (Practical) 1 Credit

List of Practical

1. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.

2. Assays based on precipitation reactions - Ouchterlony double diffusion (ODD) & Single radial immunodiffusion (SRID) (Mancini method).

3. Immunoelectrophoresis.

4. Enzyme linked immune-sorbent assay (ELISA) (Demonstration only).

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 Paper 15- Molecular Diagnostics (Theory) 3 Credits

Unit-I

Introduction To Biochemical Diagnostics

Inborn errors of metabolism

Inborn error of metabolism (phenylketonuria, alkaptonuria, albinism, MSUD, glycogen storage disease, lipid storage disease, GM1 gangliosidosis, Tay Sachs disease, Fabry's disease, Gauchers disease, Niemann pick disease – cause)

Diagnostic Enzymes

Diagnostic enzymes – clinical significance of aspartate aminotransferase, alanine aminotransferase, creatine kinase, aldolase, lactate dehydrogenase), tests for determination of myocardial infarction (enzymes, troponin, myoglobin), enzymes of pancreatic origin and biliary tract.

Unit- II

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

Core Paper 15P Molecular Diagnostics (Practical) 1 Credit

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.

SEMESTER 7

Core Paper 16- Molecular Basis of Infectious disease (Theory) 3 Credits

Unit I

Molecular basis of Infectious Diseases

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.

Epidemiology and Public health

Science of Epidemiology, Disease outbreak, Disease transmission, Diagnosis of Infectious diseases, Disease prevention

Unit II

Overview of diseases caused by infectious agents (brief introduction)

Bacterial: 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 Cholera,Typhoid, Diphtheria, Pertussis, Tetanus and Pneumonia.(Mode of action of Diptheria toxin, Tetenustoxin,Cholera toxin)

Viral: Viral diseases including AIDS, hepatitis (A, B, C), influenza and polio: causative agents, Pathogenesis; Dengue & chikungunya.

Parasitic: 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.

Fungal: Aspergillosis (brief introduction)

Core Paper 16P- Molecular Basis of Infectious disease (Practical) 1 Credit

List of Practical

1. Identification of bacterial contamination (CFU) from water, soil

2. Antibiotic assay by i) Cup plate method ii) Serial dilution method

(Determination of MIC)

3. PCR based diagnosis (Demo & tutorial only)

4. Dot Blot & ELISA based diagnosis (Demo & tutorial only)

5. Permanent slides of pathogens. *Mycobacterium tuberculosis, Leishmania, Plasmodium falciparum*

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
- Principles of Microbiology (2015) Second Ed., Ronald M.Atlas

Core Paper 17- Microbial Genetics and Biostatistics (Theory) 3 Credits

Unit-I

Genome Organization and Mutations

Genome organization: E. coli, Saccharomyces, Tetrahymena

Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes Plasmids: Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids.

Unit II

Mechanisms of Genetic Exchange

Transformation: Discovery of Transformation, Competence, Regulation of competence in B. subtilis, Experimental evidence for models of natural transformation, Plasmid transformation and phage transfection of naturally competent bacteria, Role of natural transformation, Importance of natural transformation for forward and reverse genetics, artificially induced competence.

Conjugation: Classification of self-transmissible plasmids, Mechanism of DNA transfer during conjugation in Gram negative bacteria, Chromosome transfer by plasmids, Formation of Hfr strains, Transfer of chromosomal DNA by integrated plasmids, Chromosome mapping of genes by interrupted mating.

Transduction: Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers

Phage Genetics
Features of T4 genetics, Genetic basis of lytic versus lysogenic switch of phage lambda
Transposable elements: Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds) Uses of transposons and transposition

Unit-III

Biostatistics
Statistical methods: Scope of statistics: utility and misuse. Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and Population, Sampling Errors, difference between parametric and non-parametric statistics;
Statistical evaluation of results-mean, mode, median calculation, standard deviation calculation, Correlation and regression, student t-test, correlation coefficient, Chi-square tests with examples of different problems.

Core Paper 17P- Microbial Genetics and Biostatistics (Practical) 1 Credit

List of Practical

1. Preparation of Master and Replica Plates

2. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells

3. Study survival curve of bacteria after exposure to ultraviolet (UV) light

4. Demonstration of Bacterial Conjugation

7. Demonstration of bacterial transformation and transduction

8. Demonstration of AMES test

Reference Books:

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

- Pelczar. M., et al., Microbiology, 5th ed.,2000, Tata-McGraw Hill
- Atlas, RM., Principles of Microbiology, 2nd ed.,1997, McGraw-Hill
- Salle, AJ., Fundamental Principles of Bacteriology, 7th ed.,1999, Tata- McGraw Hill
- Prescott, LM., Microbiology, 6th ed. 2005, McGraw-Hill.
- Biostatistics: A Foundation for Analysis in the Health Sciences (2009) 9th ed., Daniel W.W., John Wiley and Sons Inc.
- Statistics at the Bench: A Step-by-Step Handbook for Biologists (2010) Bremer, M. and Doerge, R.W., Cold Spring Harbor Laboratory Press (New York), ISBN: 978-0-879698-57-7.

Core Paper 18- Advanced Cell Biology (Theory) 3 Credits

Unit I

1.Nuclear transport

Transport across nuclear envelope, regulation of nuclear protein import and export

2. Cell Signaling

Molecular mechanisms of signal transduction, receptor tyrosine kinase and tyrosine kinase based signaling, insulin signal transduction, MAP kinase signaling cascade, JAK STAT pathway, signaling in microorganisms and plants, sensory transduction in vision, olfaction and gustation.

Hormone mediated signalling
Intracellular and extracellular receptors, hormone-receptor binding, scatchard analyses, mechanism of functions of secondary messengers (GPCR, cAMP, cGMP, IP3, DAG, Ca2+, NO), effector systems (AC, GC, PDE, PLC).

Unit II

3. Cell, Cell Cycle and Cell Death

Overview of cell cycle, regulation of cell cycle by protein kinase-cyclin.

Types of cell death, apoptosis, features and pathways of apoptosis, Bcl2 family proteins, necrosis, causes of necrosis, mechanism of necrosis,

Stem cells and maintenance of adult tissues, hematopoiesis, embryonic stem cells and therapeutic cloning.

Unit III

4. Cancer Biology

Transformation of cells, characteristics of neoplastic cells, hallmarks of cancer, stages of cancer, causes of cancer, cell cycle abnormalities and cancer, cancer causing mutations, gain-of function mutation, loss-of function mutation, tumour viruses, cancer metastasis, molecular approach to cancer treatment.

Core Paper 18P- Advanced Cell Biology (Practical) **1 Credit**

List of Practical

1. Cell count of RBC/Yeast cell by haemocytometer.
2. Study of morphology of cancer cells (photomicrographs)
3. Biopsy for diagnosis of cancer (demonstration)
4. Mitosis study in onion root tip
5. Microscopic measurement of bacterial / yeast cell (micrometry)
6. Study of cell viability/death assay by use of trypan blue
7. Study of apoptosis through analysis of DNA fragmentation assay (ladder assay) (demonstration)

Reference Books:

- Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6 edition. John Wiley & Sons. Inc.
- Alberts, B., Johnson,A., Lewis, J., and Enlarge, M. 2008 Molecular Biology of the Cell. 5th ed., Garland Science (Princeton),
- Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J. 2012. Molecular Cell Biology. 7th ed., W.H. Freeman & Company (New York),
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
- 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 Biochemistry (2011) 4th ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

Core Paper 19: Advanced Biochemistry (Theory) 3 Credits

Unit-I

Protein Structure and Protein Folding

Ramachandran Diagram and its significance in Protein Structure. Protein domain, subunit interactions. Three-dimensional structure of Myoglobin, quaternary structure of Hemoglobin, 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.
Protein folding, Denaturation and renaturation of protein-Ribonuclease A.
Protein folding monitoring by circular dichroism (CD) spectroscopy, pulsed HD exchange followed by 2D-NMR spectroscopy or mass spectrometry and fluorescence resonance energy transfer (FRET).Protein folding events-burst phase,hydrophobic collapse, molten globule. Assisted folding by molecular chaperones (Hsp 70, Hsp40), chaperonins (GroEL,GroES) and PDI. Defects in protein folding and diseases –Alzheimer's and Prion based. Proteostasis, Autophagy.

Unit-II

Different types of biomolecular interactions

Molecular interaction mechanisms and forces between molecules: selectivity, affinity,kinetics and thermodynamics. Various types of biomolecular interactions: protein ligand (Hb-O_2,Mb-O_2 ,steroid hormone receptor) ,protein-protein (Hb subunit interactions, protease-inhibitor complex), DNA-protein (DNA-Transcription factors-Lac repressor).Techniques to study biomolecular interaction for DNA-small molecule, DNA-protein, protein-protein interactions by absorption spectroscopy, fluorescence spectroscopy, FRET, SPR, ITC, Thermal melting, DNA footprinting, CHIP assay, Co-IP, pull down assay.

Unit-III

Drug discovery and development

Modern method and principles of drug discovery and development. Computational techniques used in drug development. Brief introduction of discovery, development & molecular mechanism of action of few drugs: salicylates, jasmonates, penicillin and insulin.Brief introduction of classical targets in drug discovery: protein, enzymes, g-protein-coupled receptors (GPCRs), ligand-gated channels. Brief introduction to pharmacophore, QSAR, chirality in drug selection, drug-drug interaction, bioavailability of drug, Basics of clinical trials: phase I, phase II, phase III and phase IV trials.

Core Paper 19P: Advanced Biochemistry (Practical) 1 Credit

List of Practical

1.Spectrophotometric quantitation of protein (Lowry) and preparation of standard curve.

2.Study of DNA-small molecule interaction by absorbance spectroscopy.

3.Analysis of protein-ligand interactions by Molecular docking/Pymol software.

4.In silico visualization of interaction of a protein with a drug (say interaction of actin and Phalloidin OR tubulin with vinca alkaloids)

Reference books:

- 1.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.
- 2.Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt.Ltd. (New Jersey), ISBN: 978-1180-25024
- 3.Principles and Techniques of Biochemistry and Molecular Biology(Seventh edition) ,edited by Keith Wilson and John Walker.
- Basic Principles of Drug Discovery and Development –by Benjamin Blass

Additional DSC/Core Paper 1- Virology (Theory) 3 Credits

Unit-I

Introduction to Viruses

Properties of viruses; general nature and important features, Subviral particles; viroids, prions and their importance, Isolation and cultivation of viruses.
Morphological characters:Capsid symmetry and different shapes of viruses with examples**.**

Viral Multiplication
Viral multiplication in the Cell:Lytic and lysogenic cycle. Mechanism of virus adsorption and entry into the host cell including genome replication and mRNA production by animal viruses, mechanism of RNA synthesis, mechanism of DNA synthesis, transcription mechanism and post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.

Description of important viruses
Salient features of the viruses infecting different hosts -Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses).

Unit-II

Role of Viruses in Disease and its prevention
Viruses as pathogens:Role of viruses in causing diseases. Prevention and control of viruses:Viral vaccines, interferons and antiviral compounds.

Cultivation and assay of viruses
Cultivation of viruses using experimental animals and cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA.

Assay of viruses
Physical and Chemical methods (Electron Microscopy and Protein andNucleic acids studies.)**,** Infectivity Assays (Plaque and end-point) Genetic analysis of viruses by classical genetic methods.

Unit-III

Pathogenesis of Viruses
Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant [TMV] and insect viruses [NPV]. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Control of Viruses and Emerging Viruses
Control of viral infections through vaccines, interferons and chemotherapeutic agents. Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus. Emerging viruses.

Virology (Practical) 1 Credit

List of Practical

1. One step growth curve for determination of virus titre.
2. Phage typing of *E.coli* bacteriophages.
3. Induction of lambda lysogen by UV radiations.
4. Studies on Specialized transduction
5. Isolation of lambda DNA and their characterization.
6. Cultivation and assay of viruses using embryonated eggs and Tissue culture Technique (demo only).

Reference Books

- Medical Virology 10 Th Edition by Morag C and Tim bury M C 1994. Churchil Livingstone, London.
- Introduction to Modern Virology 4th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell Scientific Publications. Oxford.

- Virology 3 rd Edition by Conrat H.F., Kimball P.C. and Levy J.A. 1994. Prentice Hall, Englewood Cliff, New Jersey.
- Text Book on Principles of Bacteriology, Virology and Immunology Topley and Wilsons, 1995.
- Molecular Biology, Pathogenesis and Control by S.J. Flint and others. ASM Press, Washington, D.C.
- Applied Virology. 1984. Edited by EdonardKurstak. Academic Press Inc.
- Introduction to Modern Virology by Dimmock.
- Prion diseases by Gaschup, M.H.
- Clinical virology Manual by Steven, S., Adinka, R.L., Young, S.A.
- Principles of Virology. 2000 by Edward Arnold.

SEMESTER 8

Core Paper 20- Molecular basis of non-infectious diseases (Theory) 3 Credits

Definition of non-infectious diseases, classification of diseases, risk factors, genetic disorders and life style disorder, role of environmental factors.

Genetic disorder

Causes, identification of gene, symptoms, diagnosis, management/ treatment for the following diseases – Huntington disease, Cystic Fibrosis, Albinism, Autism, Hemophilia, Myotonic dystrophy, Perkinson disease, Fragile X syndrome

Life style disorder

Causes, symptom, diagnosis, treatment / management, Diabetes, Hypertension, Obesity, Hypothyroidism, Cardio vascular disease, Atherosclerosis, Irritable bowel syndrome

Cancer

Important aspects of biochemical and genetic features of cancerous cell, important properties of oncogenes and tumor suppressor genes, concepts of genetic instability, aneuploidy and angiogenesis, telomerase activity and cancer, p53 mutation and cancer, retinoblastoma, burkitts lymphoma, BCR-ABL genetic tests, use of tumor biomarkers for treatment and detection (PSA, AFP, calcitonin, CEA, β-HCG, monoclonal immunoglobulin, ER, PR, HER-2, BRCA1, BRCA2, EGFR, KRAS, CA-125)

Other diseases

Age related diseases (osteoarthritis, COPD, Alzheimer disease, dementia), Prion disease.

Core Paper 20P- Molecular basis of non-infectious diseases (Pracitcal) 1 Credit

List of Practical

1. Estimation of glycosylated Hb in human blood
2. Estimation of serum cholesterol
3. Estimation of Blood Urea by enzymatic method
4. Permanent slides of different types of cancer

Reference Books:

- Alberts, B., Johnson,A., Lewis, J., and Enlarge, M. 2008 Molecular Biology of the Cell. 5th ed.,Garland Science (Princeton)

➢ Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J. 2012. Molecular Cell Biology. 7th ed., W.H. Freeman & Company (New York)
➢ Textbook of Biochemistry for Medical students, 7th Edition, DM Vasudevan, Sreekumari S, Kannan Vaidyanathan

Core Paper-21-Regulation of Gene Expression (Theory) 3 Credits

Unit-I
Regulation of Bacterial Gene Expression

Regulation of Gene Expression: Genes and Operons

Transcriptional regulation in bacteria, Negative regulation of transcription initiation, Positive regulation of transcription initiation, Regulation by transcription attenuation, Regulation of mRNA Degradation, Regulation of Translation, Post translational regulation.

Various families of gene regulatory proteins: helix-turn-helix, helix-loop-helix, homeodomain, leucine zipper and zinc finger families of transcription finger.

Global Regulation: Regulons and Stimulants

Carbon Catabolite Regulation, Regulation of Nitrogen Assimilation, Regulation of Ribosome and tRNA Synthesis, Stress Responses in Bacteria, Iron Regulation in *E.coli,* Regulation of virulence genes in pathogenic bacteria: Diphtheria, Cholera and quorum sensing, Whooping Cough.

Unit-II
Regulation of Eukaryotic Gene Expression

Ways of Regulating Eukaryotic Gene Expression: An Overview

Dimensions of Eukaryotic gene regulation, Controlled transcription of DNA, Alternate Splicing of RNA, Cytoplasmic control of mRNA stability.

Induction of Transcriptional Activity by Environmental and Biological Factors

Temperature: The heat-shock genes, Signal Molecules: Genes that responds to hormones.

Molecular Control of Transcription in Eukaryotes

DNA sequences involved in the control of transcription, Transcription Factors.

Posttranscriptional Regulation of Gene Expression by RNA Interference

RNAi Pathways, Sources of Short Interfering RNAs and microRNAs

Gene Expression and Chromatin Organization

Euchromatin and Heterochromatin, Molecular organization of transcriptionally active DNA, Chromatin remodelling, DNA methylation, Imprinting.

Activation and Inactivation of Whole Chromosomes

Inactivation of X chromosomes in mammals, Hyperactivation of X chromosomes in *Drosophila,* Hypoactivation of X chromosomes in *Caenorhabditis*.

Unit-III
Gene Regulation in Bacteriophages

Introduction to lytic and lysogenic cycles in Bacteriophages (T4 and l), l DNA and its gene organization, transcription of l DNA, Genetic experiments that gave insight into lytic regulation, Lysogeny: immunity and repression l cI repressor transcribed from two promoters, the operator: DNA binding by repressor and Cro, lysogeny and Prophage integration, tests for lysogeny, Prophage integration, Insertion defective mutants, Int-Promoted recombination, Integrase Reaction, Coupling of synthesis of Integrase and the cI Repressor, Prophage excision, the xis gene, Avoidance of excision during lysogeny, Prophage induction, Decision between lysis and lysogeny, Dilysogens, other modes of lysogeny, Some properties of lysogens.

Core Paper-21P- Regulation of Gene Expression (Practical)
1 Credit

List of practical

1. Northern blotting (Demo only).
2. Western blotting (Demo only).
3. Study and plot the growth curve of E. coli by turbidometric and standard plate count methods.
4. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.
5. Effect of temperature and pH on growth of E. coli.

Reference Books:

- Molecular Genetics of Bacteria (4th Edition, 2013 ASM Press, ISBN: 978-1-5581-892-0) Larry Snyder, Joseph E. Peters, Tina M. Henkin and Wendy Champness.
- Prescott's Microbiology (12th Edition, 2023 McGraw Hill, ISBN: 978-1-265-12303-1) Joanne Willey, Kathleen Sandman, and Dorothy Wood.
- Genetics (6th Edition 2012, John Wiley & Sons, Inc. ISBN: 978-1-118-09242-2) D. Peter Snudstad and Michael J. Simmons.
- Microbial Genetics Jones and Bartlett Series in Biology (2nd Edition Jones and Bartlett Publishers, Inc. ISBN: 978-0-867-20248-9) Stanley R. Maloy, John E. Cronan, Jr., and David Freifelder.

Core Paper-22 Plant Biochemistry (Theory) 3 Credits

Introduction to Plant cell structure

Plant Cell wall, Vacuole and tonoplast membrane, plastids and peroxisomes.

Photosynthesis and Carbon assimilation

Basic Structure of PSI and PSII complexes, Light reaction, Cyclic and non-cyclic photophosphorylation, Basic concepts of Calvin cycle and regulation, C3 & C4cycle, CAM pathway, Photorespiration (Concept only).

Respiration

Plant glycolysis with alternative reactions, Regulation of plant glycolysis, Glyoxalate cycle, TCA cycle, Electron transport chain in Chloroplast, Alternative NAD(P)H oxidative pathways, Cyanide resistant respiration (Concept only).

Nitrogen metabolism

Nitrogen Cycle (Concept only), Overview of Biological Nitrogen fixation (BNF), Biological Nitrogen fixation by free living and in symbiotic association, Enzymes involved in BNF, Basic concepts of structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Preliminary concepts of Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase glutamine oxoglutarate amino transferase (GS-GOGAT) pathway.

Regulation of plant growth

Introduction to plant growth regulators/ plant hormones (IAA/Auxin, Gibberellins, Cytokinin, Ethylene, Abscisic acid and Jasmonic acid) and their effect on plant growth and development (basic concept only), Regulation of plant morphogenetic processes by light (Concept only).

Plant secondary metabolites

Definitions, Classifications and functions with examples of plant secondary metabolites (Alkaloids, flavonoids, terpenoids), biological role of plant phenolics.

Plant tissue culture (Concept only)

Cell and tissue culture techniques, types of cultures: organ and explants culture,callus culture,cellsuspensionculture and protoplast culture. Applications of cell and tissue culture.

Core Paper 22P- Plant Biochemistry (Practical)
1 Credit

List of Practical

1. Estimation of Chlorophyll content from green leaves by using spectrophotometer.

2. Detection of carbohydrates from plant extract.
3. Separation of photosynthetic pigments from green leaves by Thin Layer Chromatography.
4. Separation of Carotenes by silica gel chromatography/TLC.
5. Culture of plants(explants)(Demo & tutorials only).

Reference Books:

- BiochemistryandmolecularBiologyofplant-Buchanan(2005)1edition.Publisher:IKInternational.ISBN-10:8188237116, ISBN-13:978-8188237111.
- Plant Physiology, 3rd ed by Lincoln Taiz and Eduardo Zeiger Hardcover: 690 pages Publisher: Sinauer Associates; 3 edition (Aug 30 2002) Language: English ISBN: 0878938230
- PlantBiochemistry(2008),CarolineBowsher,Martinsteer,AlysonTobin,GarlandscienceISBN978-0-8153-4121-5
- PlantBiochemistry byP.MDeyandJ.B.Harborne(Editors)(1997)Publisher:AcademicPress

Additional DSC/Core Paper 2
Advanced Techniques in Modern Biology-I (Theory) 3 Credits

Unit-I

Spectroscopic techniques:

Principle and use of study of absorption spectra of biomolecules. CD Spectroscopy and determination of 2D structures, Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry

Fluorescence Spectroscopy- physical basis and application of fluorescence spectroscopy., Jablonski diagram, measurement of fluorescence, quenching, protein folding studies, resonance energy transfer, chemiluminescence.

Infrared Spectroscopy - modes of molecular vibrations, vibration of a diatomic molecule; application of Hooke's law, characteristic stretching frequencies of O-H, NH, 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.

1H NMR Spectroscopy – introduction, nuclear spin, NMR active molecules, basic principles of NMR, choice of solvent and internal standard, equivalent and non-equivalent protons, chemical shift and factors influencing it, ring current effect, significance of the terms: upfield, downfield, shielded and deshielded protons; spin coupling and coupling constant (basic concept), Pascal's triangle.

Brief outline of Mass Spectrometry

.

Microscopic techniques

Definition, classification, workflow, applications and data analyses for visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells (confocal and immunofluorescence microscopy), scanning and transmission electron microscopy, fixation and staining techniques for light and EM, image processing.

Advanced Techniques in Modern Biology-I (Tutorial) 1 Credit

1. Visit to a laboratory and presentation of laboratory note books on different techniques seen.
2. Study of fluorescent micrographs to visualize bacterial cells.

3. Ray diagrams of phase contrast microscopy and Electron microscopy.

4. Determination of λmax for an unknown sample and calculation of extinction coefficient.

5. Understanding density gradient centrifugation with the help of pictures.

Reference Books

- Biological instrumentation and methodology by Dr. P.K. Bajpai
- Techniques and methods in Biology by K.L. Ghatak
- Experimental procedures in Life Sciences by S. Rajan and R. Selvi Christy
- Methodology of Biological Science by R. Bakkappa
- Principles and techniques of Biochemistry and Molecular Biology by Wilson and Walker
- Tools and techniques in Biological Science by Dev, Vats and Chaturvedi
- A Book on Biological techniques by Pawar and Desai

Additional DSC/Core Paper 3-
Advanced Techniques in Modern Biology-2 (Theory) 3 Credits

Electrophoresis: Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis

Histochemical and immunotechniques
Definition, classification, workflow, data analyses and applications of flowcytometry, FACS, in-situ hybridization techniques (FISH, GISH, IHC and detection of molecules in living cells).

Molecular Biology and recombinant DNA methods
Definition, classification, work flow and applications of molecular cloning of DNA or RNA fragments in prokaryotic and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors (Ti plasmids), isolation of specific nucleic acids sequences, generation of genomic and cDNA libraries in plasmid, cosmid, BAC, YAC vectors. Agrobacterium mediated gene transfer; Ti Plasmid, T-DNA (outline).

Sequencing techniques
Definition, classification, workflow and applications of different DNA sequencing methods (Sanger di-deoxy and modified Sanger di-deoxy), strategies for genome sequencing (NGS), RNA-sequencing, analyses of gene expression at RNA and protein level (microarray), RFLP, RAPD, AFLP, PCR, q-PCR, semiquantitative PCR (ct values, curves, image analyses)

Computational methods

Concept of homology, paralogy, orthology, analogy and xenology, Basic idea of data mining methods for sequence analyses, nucleic acid and protein sequence databases (NCBI, PDB), Web-based tools for sequence searches (sequence alignment, sequence homology). Introduction to Bioinformatics- Gene bank, NCBI, DDBJ, Swissprot, PDB. Sequence alignments- BLAST and FASTA (Demonstration).

Advanced Techniques in Modern Biology-II (Tutorial) 1 Credit

1. Working with BLAST (blastx, blastn, blastp, tblastn)
2. Multiple Sequence Alignment and construction of phylogenetic tree by using different webtool.
3. DNA Fingerprinting (Using RFLP Technique- kit based)
4. Cell cycle analysis by Flow cytometry. (Demo)

Reference Books

- Biological instrumentation and methodology by Dr. P.K. Bajpai
- Techniques and methods in Biology by K.L. Ghatak
- Experimental procedures in Life Sciences by S. Rajan and R. Selvi Christy
- Methodology of Biological Science by R. Bakkappa
- Principles and techniques of Biochemistry and Molecular Biology by Wilson and Walker
- Tools and techniques in Biological Science by Dev, Vats and Chaturvedi
- A Book on Biological techniques by Pawar and Desai

Skill Enhancement Courses (SEC)

SEMESTER 1

BCM-SEC-1-1: Tools and Techniques in Biochemistry (Theory) 3 Credits

Unit I

Basic Lab Practices and Preparation of Solutions

Safety practices in the laboratory, preparation and storage of solutions, concepts of solution concentration and storing solutions: Standard solutions, molar, normal, molal, formal and percent strengths, quantitative transfer of liquids.

Special chemical requirement of biomolecules, factors affecting analyte structure and stability, pH, temperature and solvent polarity, buffering systems used in biochemistry, concept of colligative properties (no derivations), osmolarity, diffusion of solutes in solution.

Basic Instruments and techniques: Working principles, basic operation and application of weighing balance, pH meter, autoclave, laminar air flow, Water Baths, CO2 Incubators, Shaking Incubators, Hot Air Ovens, Bio-Safety Hoods.

Pipettes and MilliQ water system.Principle of asepsis and sterilization technique.

Unit-II

Microscopy – Working principles, basic operation and application of Light and phase contrast microscope.

Centrifugation techniques: Sedimentation (Sedimentation coefficient, Svedberg unit), Centrifugation: Working principles, basic operation and application of micro-centrifuge, ultracentrifuge and density gradient centrifugation, applications (isolation of cell components).

Different Biophysical Techniques

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.

SEC 1P: Tools and Techniques in Biochemistry (Practical) 1 Credit

List of Practical

1. Safety measure in laboratories, use and calibration of pipettes
2. Preparation of normal, molar and percent solutions
3. Standardization of NaOH and acetic acid solutions

4. Concept of pH and preparation of buffers, pH metric titration of a weak acid with a strong base.

5. Determination of extinction coefficient of different BSA solutions by spectrophotometer.

Reference Books:

- Physical Chemistry - P. C. Rakshit
- Lehninger Principles of Biochemistry - Nelson & Cox Text Book of Physical Chemistry - K. L. Kapoor
- Physical Chemistry-Hrishikesh Chatterjee
- Techniques and Methods in Biology - K. L. Ghatak
- Physical Biochemistry: Principles and Applications - D. Sheehan,
- Physical Biochemistry: Applications to Biochemistry and Molecular Biology – D. Freifelder
- An Introduction to Practical Biochemistry – D. T. Plummer
- Molecular Spectroscopy - C. N. Banwell&McCash Organic Spectroscopy - William Kemp

SEMESTER 2

BCM-SEC-2-1 Protein Purification Techniques (Theory) 3 Credits

Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques-

1. **Protein Isolation-** Methods of solubilization of proteins from their cellular and extra-cellular locations- cytosolic, integral and peripheral membrane protein. Brief outline of the use of simple grinding methods, homogenization, ultrasonication, French press and centrifugation, sedimentation coefficient, stabilization of proteins during purification.

2. **Solubility of Proteins based on Protein Purification**- Salting in and salting out (Ammonium sulphate fractionation), solvent fractionation, Isoelectric precipitation), lyophilization,
   Dialysis, Ultrafiltration (Principle and application), Ultracentrifugation

3. **Chromatographic Separation:** partition coefficient, phase systems, liquid and gas chromatography, performance parameters: retention, resolution, basis of peak broadening, peak symmetry, Principle, Application, Advantages and Disadvantages, limitation for different modes of chromatography- Partition Chromatography (Paper Chromatography, hydrophobic interaction/ reverse phase chromatography), Adsorption Chromatography ;Thin Layer Chromatography, Gel filtration chromatography, affinity chromatography, Ion-exchange chromatography, Demonstration of High Performance Liquid Chromatography (HPLC), brief concept of FPLC.
4. **Electrophoresis Techniques**: Brief concept of Paper electrophoresis, Principle and application of different types of Gel Electrophoresis (PAGE- horizontal and vertical, SDS-PAGE and molecular weight determination, Isoelectric Focusing (IEF) and 2-D gel electrophoresis, Capillary Electrophoresis (CE).

5. Determination of purity, specific activity, extinction coefficient of enzymes / proteins. Mass Spectrometry (Principle and application only).

SEC3P- Protein Purification Techniques (Practical) 1 Credit

List of Practical

1. Assay of enzyme activity and specific activity of Alkanine Phosphatases
2. Determination of Molecular weight of protein from SDS-PAGE (kit based)
3. Column chromatography (size exclusion) by teaching kit (Determination of Void volume)

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

SEMESTER-3

BCM-SEC-3-1Clinical Biochemistry (Theory) 3 credits

Unit I

Introduction to Clinical Biochemistry

Definition of Clinical Biochemistry and significance of diagnosing a disease with specific biological sample (serum, plasma, CSF, urine and faeces), Collection and preservation of serum, plasma and urine, Use of anticoagulants, Instrumentation (colorimeter, spectrophotometer) – automation (auto analyzer and semi-autoanalyzer), significance of calibration, precision, accuracy, specificity, sensitivity, quality control

Unit II

Diagnostic biochemical profile

Assessment of glucose metabolism in blood – clinical significance in variation of blood glucose, glucose tolerance test (OGTT, EGTT), Diabetes Mellitus – types, cause, symptoms, treatment, HbA1c, Lactose intolerance.

Lipid profile – composition and function of lipoproteins, clinical significance of elevated lipoproteins (atherosclerosis, hypertension, blood pressure – normal range and factors leading to high blood pressure)

Liver function test – function of liver, tests to assess liver function – serum bilirubin (total, conjugated, unconjugated), urine – bile pigments, bile salts, urobilinogen, liver enzyme tests – ALT, AST, ALP, GGT, plasma protein, serum albumin, globulin, A/G ratio, prothrombin time, blood ammonia, tests based on liver's part in carbohydrate metabolism (glucose tolerance test, galactose tolerance test), tests based on detoxicating functions of liver (hippuric acid test), Jaundice and its classification (haemolytic, hepatic, obstructive, neonatal)

Renal function test – function of kidney, classification of renal function test – complete urine analysis, plasma urea, creatinine and electrolytes, GFR and its markers (creatinine clearance test, urea clearance test, inulin clearance test), tubular function test (concentration test, dilution test, urinary acidification), use of urine strip / dip stick method of urine analysis, normal and abnormal constituents of urine

Reference books

- Medical Laboratory Technology - a Procedure Manual for Routine DiagnosticTests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw–Hill Publishing CompanyLimited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631
- Medical Laboratory Technology - a Procedure Manual for Routine DiagnosticTests VoI. II (2010), Mukherjee, K.L., Tata Mc Graw – Hill Publishing CompanyLtd. (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. andDeshpande, V., IK International Pvt. Ltd. (New Delhi), ISBN:81-88237-41-8
- Textbook of Medical Biochemistry, eighth edition., Chatterjee, M.N.; Shinde, R.Textbook of Biochemistry for Medical students, sixth edition, Vasudevan, D.M.; Sreekumari, S.; Vaidyanathan, K.
- Harpar's Illustrated Biochemistry.

Clinical Biochemistry (Practical) **1 Credit**

1. Clinical Biochemistry laboratory practices and biosafety
2. Estimation of serum alkaline phosphatase
3. Estimation of lipid profile –
   i) cholesterol
   ii) triglyceride
   iii) HDL cholesterol (demonstration only)
   iv) LDL cholesterol (calculation using Friedwald equation)
4. Estimation of serum LDH activity (Demonstration)

Subject- BIOCHEMISTRY

Scheme for Biochemistry Minor Curriculum

Semester	Course Name	Paper Code	Course Detail	Credits
I	Paper 1	BCM-H -CC1-1-TH	Biomolecules	3
	Paper 1 Practical	BCM-H -CC1-1-P	Biomolecules	1
II	Paper 2	BCM-H-CC2-2-TH	General and Organic Chemistry	3
	Paper 2 Practical	BCM-H-CC2-2-P	General Organic Chemistry	1
III	Paper 1	BCM-H-CC1-3-TH	Biomolecules	3
	Paper 1 Practical	BCM-H-CC1-3-P	Biomolecules	1
IV	Paper 2	BCM-H-CC2-4-TH	General and Organic Chemistry	3
	Paper 2 Practical	BCM-H-CC2-4-P	General Organic Chemistry	1
V	Paper 3	BCM-H -CC3-5-TH	Enzymology	3
	Paper 3 Practical	BCM-H -CC3-5-P	Enzymology	1
VI	Paper 4	BCM-H-CC4-6-TH	Nutritional Biochemistry	3
	Paper 4 Practical	BCM-H-CC4-6-P	Nutritional Biochemistry	1

Minor courses Detailed Syllabus

SEMESTER 1

Paper 1: Biomolecules (Theory) **3 Credit**

Unit-I

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).

Introduction to 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 (alanine, glutamic acid, lysine), Formol titration of glycine (only reaction and principle), reaction of amino acids ninhydrin and fluorescamine, separation and analysis of amino acids by paper & thin layer chromatography.

Unit-II

Introduction to peptides & proteins:

Peptide bond: Definition, structure and geometry of peptide bond, peptide bond lengths and configuration. Nature of stabilizing bonds - covalent and non-covalent forces. Example of biologically important peptide and its functions in brief (glutathione-peptide of non protein origin). 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 of 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, 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)

Unit-III

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. cofactors and pigments (preliminary ideas only).

Nucleic acids:

Nucleotides - structure and properties. Nucleic acid structure--- Watson-Crick model of DNA. Forms of DNA (A, B and Z DNA), Structure and function of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - DNA UV absorption, effect of acid and alkali on DNA and RNA. DNA melting, T_m value of DNA, hyperchromic shift of A_{260} of dsDNA during denaturation. Other functions of nucleotides - source of energy (nucleoside triphosphates), component of coenzymes (FAD, NAD^+), second messengers (cAMP, cGMP).

Reference books:

- 1. 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.
- 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. Harper's Illustrated Biochemistry(27th edition),ISBN-13:978-0071253017
- 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
- 5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin,
- T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

Biomolecules (Practical) **1 Credit**

List of Practical

6. Separation of amino acids by thin layer chromatography.
7. Qualitative test for carbohydrate.
8. Qualitative test for lipid.
9. Qualitative test for amino acids & proteins.
10. Assay of proteins using Lowry method, standard curve preparation.

SEMESTER 2

Paper 2: General and Organic Chemistry (Theory) 3 Credits

Unit I
Atomic Structure (Briefly)

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), Groundstate term symbols of atoms and ions (concept only).

Intermolecular forces

e. 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.

f. 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 H2 and O2 molecular orbitals , sigma and pi bonds, multiple bonding. Concept of Bond order, bond length, bond strength, bond energy.

g. Weak Chemical Forces

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

h. 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.

Radioactivity and the applications of radioactive isotopes

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

Reference Books

6. General &Inorganic Chemistry - R.P.Sarkar
7. Inorganic Chemistry - R.L.Dutta
8. New Concise Inorganic Chemistry - J.D.Lee
9. Inorganic Chemistry, Principles of Structure and Reactivity - J.E.Huheey, E.A.Keiter, & R.L.Keiter
10. Fundamental Concepts of inorganic Chemistry – A.K.Das

Unit 2

Basic Concept of Organic Chemistry (GOC):

Concept of hybridisation, inductive effect, resonance, hyperconjugation, Steric Effect, dipole moment, bond distance, and 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).

Aromaticity: Huckel's rules for aromaticity, antiaromaticity, nonaromaticity & homoaromaticity.

Type of reactions: Ionic, radical and pericyclic (concept only) reactions; Type of bond cleavage: heterolytic and, homolytic bond cleavage; Type of reagents: electrophile and nucleophile. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate.

Stereochemistry of Carbon Compounds:

Stereochemistry Optical activity of chiral compounds: specific rotation, measurement of specific rotationby polarimeter, racemisation (general principle) resolution of simple acids and bases. Representation of molecules in saw horse, Fischer, flyingwedge and Newman formulae and their inter translations, Configuration: i) systems involving 1, 2, 3 stereocentres, 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. Conformation: 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.

General treatment of Reaction mechanism and kinetic study:

Reaction kinetics: transition state theory, rate constant and free energy of activation, free energyprofiles for one step and two step reactions (concept only).

Nucleophilic substitution reactions: Substitution reactions involving S_N1, S_N2 and S_Ni mechanisms. Effectof substrate structure, nucleophiles (including ambident nucleophiles), solvent and leaving group; substitution involving neighboring group participations (NGP).

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

Aromatic Electrophilic and Nucleophilic substitution: Electrophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions) and activated nucleophilic substitution reactions.

Addition reactions to multiple bonds and carbonyl groups: Addition reactions to Carbon–carbon multiplebonds-Electrophilic additions mechanisms (concept only), dihydoxylation (1,2-diol), ozonolysis. Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$; oxidation of alcohols with PCC; oxidation of 1,2-diols using periodic acid and lead tetraacetate. Formation of acetal/ketal, Cannizzaro (including cross-Cannizzaro), aldol condensation (including directed and cross aldol condensation).

Organometallics and Heterocycles:

Organometallic chemistry: Grignard reactions (including abnormal behavior) and Corey-House synthesis (Gilman Catalyst, R_2CuLi).

Heterocycles: Structural aspects of five and six membered heterocycles containing hetero atoms (pyrrole, furan, thiophene and pyridine). Reactivity towards electrophilic and nucleophilic substitution (Concept only).

Reference Books

8. Organic Chemistry (vol.1&2) - I.L.Finar
9. A Guide to Organic Reaction Mechanism - P.Sykes
10. Organic Chemistry - P.Wothers, N.Greeves, J.Clayden, & S.Warren
11. Organic Chemistry - G.M.Loudon
12. Stereochemistry of Carbon Compounds - D.Nasipuri
13. Basic Stereochemistry of Organic Compounds - S.Sengupta
14. Stereochemistry of Organic Compounds - E.L.Eliel, & S.H.Wilen

General and Organic Chemistry (Practical) **1 Credit**

V. Physical characteristics (colour, odour, texture)
VI. Solubility and classification (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)
VII. Detection of special elements (N, Cl, S) by Lassaigne's tests.
VIII. Detection of the following functional groups by systematic chemical tests: (aromatic amino ($–NH_2$), aromatic nitro ($– NO_2$), Amido ($–CONH_2$, including imide), 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 practicalexamination, 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.**

LABORATORY RECORDS

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. Marksof 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:

(iii) Advanced Practical Chemistry – Subhas Ch. Das
(iv) Handbook of Practical Chemistry – University of Calcutta

SEMESTER 3

Paper 1: Biomolecules (Theory) 3 Credit

Unit-I

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).

Introduction to 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 (alanine, glutamic acid, lysine), Formol titration of glycine (only reaction and principle), reaction of amino acids ninhydrin and fluorescamine, separation and analysis of amino acids by paper & thin layer chromatography.

Unit-II

Introduction to peptides & proteins:

Peptide bond: Definition, structure and geometry of peptide bond, peptide bond lengths and configuration. Nature of stabilizing bonds - covalent and non-covalent forces. Example of biologically important peptide and its functions in brief (glutathione-peptide of non-protein origin). 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 of 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, 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)

Unit-III

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. cofactors and pigments (preliminary ideas only).

Nucleic acids:

Nucleotides - structure and properties. Nucleic acid structure--- Watson-Crick model of DNA. Forms of DNA (A, B and Z DNA), Structure and function of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - DNA UV absorption, effect of acid and alkali on DNA and RNA. DNA melting, T_m value of DNA, hyperchromic shift of A_{260} of dsDNA during denaturation. Other functions of nucleotides - source of energy (nucleoside triphosphates), component of coenzymes (FAD, NAD^+), second messengers (cAMP, cGMP).

Reference books:

- 1. 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.
- 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. Harper's Illustrated Biochemistry(27th edition),ISBN-13:978-0071253017
- 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
- 5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin,
- T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

Biomolecules (Practical) 1 Credit

List of Practical

11. Separation of amino acids by thin layer chromatography.
12. Qualitative test for carbohydrate.
13. Qualitative test for lipid.
14. Qualitative test for amino acids & proteins.
15. Assay of proteins using Lowry method, standard curve preparation.

SEMESTER 4

Paper 2: General and Organic Chemistry (Theory) 3 Credits

Unit I
Atomic Structure (Briefly)

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), Groundstate term symbols of atoms and ions (concept only).

Intermolecular forces

i. 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.

j. 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 H2 and O2 molecular orbitals , sigma and pi bonds, multiple bonding. Concept of Bond order, bond length, bond strength, bond energy.

k. Weak Chemical Forces

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

l. 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.

Radioactivity and the applications of radioactive isotopes

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

Reference Books

11. General &Inorganic Chemistry - R.P.Sarkar
12. Inorganic Chemistry - R.L.Dutta
13. New Concise Inorganic Chemistry - J.D.Lee
14. Inorganic Chemistry, Principles of Structure and Reactivity - J.E.Huheey, E.A.Keiter, & R.L.Keiter
15. Fundamental Concepts of inorganic Chemistry – A.K.Das

Unit 2

Basic Concept of Organic Chemistry (GOC):

Concept of hybridisation, inductive effect, resonance, hyperconjugation, Steric Effect, dipole moment, bond distance, and 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).

Aromaticity: Huckel's rules for aromaticity, antiaromaticity, nonaromaticity & homoaromaticity.

Type of reactions: Ionic, radical and pericyclic (concept only) reactions; Type of bond cleavage: heterolytic and, homolytic bond cleavage; Type of reagents: electrophile and nucleophile. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate.

Stereochemistry of Carbon Compounds:

Stereochemistry Optical activity of chiral compounds: specific rotation, measurement of specific rotationby polarimeter, racemisation (general principle) resolution of simple acids and bases. Representation of molecules in saw horse, Fischer, flyingwedge and Newman formulae and their inter translations, Configuration: i) systems involving 1, 2, 3 stereocentres, 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. Conformation: 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.

General treatment of Reaction mechanism and kinetic study:

Reaction kinetics: transition state theory, rate constant and free energy of activation, free energyprofiles for one step and two step reactions (concept only).

Nucleophilic substitution reactions: Substitution reactions involving S_N1, S_N2 and S_Ni mechanisms. Effectof substrate structure, nucleophiles (including ambident nucleophiles), solvent and leaving group; substitution involving neighboring group participations (NGP).

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

Aromatic Electrophilic and Nucleophilic substitution: Electrophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions) and activated nucleophilic substitution reactions.

Addition reactions to multiple bonds and carbonyl groups: Addition reactions to Carbon–carbon multiplebonds-Electrophilic additions mechanisms (concept only), dihydoxylation (1,2-diol), ozonolysis. Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$; oxidation of alcohols with PCC; oxidation of 1,2-diols using periodic acid and lead tetraacetate. Formation of acetal/ketal, Cannizzaro (including cross-Cannizzaro), aldol condensation (including directed and cross aldol condensation).

Organometallics and Heterocycles:

Organometallic chemistry: Grignard reactions (including abnormal behavior) and Corey-House synthesis (Gilman Catalyst, R_2CuLi).

Heterocycles: Structural aspects of five and six membered heterocycles containing hetero atoms (pyrrole, furan, thiophene and pyridine). Reactivity towards electrophilic and nucleophilic substitution (Concept only).

Reference Books

15. Organic Chemistry (vol.1&2) - I.L.Finar
16. A Guide to Organic Reaction Mechanism - P.Sykes
17. Organic Chemistry - P.Wothers, N.Greeves, J.Clayden, & S.Warren
18. Organic Chemistry - G.M.Loudon
19. Stereochemistry of Carbon Compounds - D.Nasipuri
20. Basic Stereochemistry of Organic Compounds - S.Sengupta
21. Stereochemistry of Organic Compounds - E.L.Eliel, & S.H.Wilen

General and Organic Chemistry (Practical) **1 Credit**

IX. Physical characteristics (colour, odour, texture)

X. Solubility and classification (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)

XI. Detection of special elements (N, Cl, S) by Lassaigne's tests.

XII. Detection of the following functional groups by systematic chemical tests: (aromatic amino ($–NH_2$), aromatic nitro ($– NO_2$), Amido ($–CONH_2$, including imide), Phenolic –OH, Carboxylic acid (–COOH), Carbonyl (>C= O); only one test for each functional group is to be reported)

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Practical Reference Books:

(v) Advanced Practical Chemistry – Subhas Ch. Das
(vi) Handbook of Practical Chemistry – University of Calcutta

SEMESTER 5

Paper 3: ENZYMOLOGY (Theory) 3 credits

UNIT I

Enzyme and Enzyme Catalysis

g. Definition of enzymes, Nature of enzymes, protein and non-protein (ribozyme), apoenzyme and holoenzyme, differences between biocatalysts and chemical catalysts.

h. Cofactors: metal ions (Zn^{+2}, Mg^{+2}, Fe^{2+}) **[one example of enzyme using metal ion with reaction],** coenzymes, (NAD+, NADP+, HSCoA, FH4, cobalamin), prosthetic groups (FAD, TPP, PALPO, biotin) [**structures not needed, vitamin precursors, two examples of enzymes for each with reactions showing proper equation]** , co-substrate (NAD+)- one example with reaction.

i. IUBMB Classification of enzymes, Name & two examples of each class with reaction

j. Concept of active site, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis. proximity and orientation effect (orbital steering hypothesis to be mentioned), strain and distortion theory (example of Lysozyme/RNase catalyzed reaction).

k. Catalytic power and specificity of enzymes (stereospecifity and geometric specificity)

l. Mechanism of enzyme catalysis (basic concepts)
   i) acid- base catalysis (example- RNase A)
   ii) Metal ion catalysis: Metal activated enzymes (eg hexokinase) and metalloenzymes (eg carbonic anhydrase)
   iii) covalent catalysis (example- chymotrypsin)

UNIT II

Enzyme kinetics

f. Definition of Transition state, definition of Activation Energy, energy profile diagram for uncatalyzed and enzyme-catalyzed reactions, rate-determining step of a reaction, multistep reactions with energy profile diagram, binding energy, transition state analogs.

g. Concepts of rate, rate constant and order of a reaction, integrated form of rate expressions of first order reaction (derivation not needed, rate equation and graph needed), half-life period and its significance.

h. Concept of pre steady state and steady state, initial rate, maximum velocity (Vmax), Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions, association and dissociation constant, Michaelis-Menten equation (derivation and graphical representation), Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. Km and Vmax, Kcat and turnover number, Kcat/Km, enzyme activity, specific activity, katal, International Unit of enzyme activity. Numerical problems on Enzyme kinetics.

i. Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, time, metal ions on the activity of enzyme (Cu^{2+}, As^{2+}, Hg^{2+}, Pb^{2+}: one example of each) .

j. Bisubstrate reactions: Sequential reactions (Ordered and Random reactions with definition and example), Ping-pong reactions (definition and example of transamination reactions), differences between sequential and ping-pong reactions.

UNIT III

Enzyme Inhibition and Regulation of Enzyme Activity

h. Reversible inhibition (competitive, uncompetitive, non-competitive, mixed – one eg of each, Michaelis-Menten equation in the presence of respective inhibitor and effect of each inhibitor on K_M and V_{max} values.)

i. Irreversible inhibition- Mechanism based inhibitors (suicide substrate or suicide inhibitor), example of an antibiotic that acts as an inhibitor (Penicillin)

j. Control of activities of single enzymes: feedback inhibition

k. Properties of Allosteric enzyme (Aspartate transcarbamoylase) and its regulation, definition of M and K enzymes, Sequential and Symmetry Model.

l. Reversible covalent modification: phosphorylation and dephosphorylation (glycogen phosphorylase and glycogen synthase).

m. Proteolytic cleavage- zymogen (chymotrypsinogen and trypsinogen).

n. Isoenzymes - properties and physiological and clinical significance (lactate dehydrogenase and creatine kinase).

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

ENZYMOLOGY (PRACTICAL) **1 credit**

List of Practical

- Standard curve of p-nitrophenol.
- Assay of enzyme activity and specific activity of Alkanine Phosphatase.
- Effect of pH on the enzyme activity.
- Effect of temperature on the enzyme activity.
- Determination of Km and Vmax using Lineweaver-Burk graph.
- Enzyme inhibition - calculation of Ki for competitive inhibition

SEMESTER 6

Paper 4: Nutritional Biochemistry (Theory) 3 Credits

Unit-I
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 (RDA) for different age groups.

Dietary carbohydrates, lipids, proteins and health

RDA, sources and functions and storage of carbohydrates, proteins and lipids in human health, essential and non-essential amino acids and fatty acids, excess, toxicity, imbalance and deficiency of amino acids and fatty acids, dietary importance/implications of MUFA, PUFA, SFA, omega fatty acids with omega3/omega 6 ratio, phospholipids, cholesterol, triglycerides, saturated fats and oils, combined ratios of n6 and n3, lipotropic factors, amino acid supplementation, amino acid pool, amino acid availability, antagonism, NPU, BV, nitrogen balance, nitrogen cycle, protein calorie malnutrition - Kwashiorkar and Marasmus.

Dietary fibres and health

Role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Unit-II

Vitamins

RDA, sources, storage, adsorption, distribution, metabolism and excretion (ADME) of fat- and water-soluble vitamins, functional role of vitamins (vitamin A as an antioxidant, in visual cycle, dermatology and immunity, vitamin B6 in pyridoxal phosphate formation, niacin-

metabolic interrelation between tryptophan, niacin and NAD/ NADP, vitamin C as cofactor in amino acid modifications, extra-skeletal role of Vitamin D and its effect on bone physiology, vitamin E as an antioxidant, vitamin K in gamma carboxylation and blood coagulation, hypervitaminosis and deficiency of vitamins with deficiency symptoms and treatment. A correlation of Vitamin B12 and folate mentioning dietary source, RDA, absorption, metabolic role and biochemical basis for deficiency symptoms.

Minerals

RDA, sources, storage, digestion, absorption, utilization, transport, excretion, balance, deficiency and distribution in human body for calcium, phosphorus, iron, iodine, fluoride, Mg, Cu, Zn, Se, manganese, chromium, molybdenum, calcium: phosphorus ratio, role of iron in prevention of anemia, iodine cycle, toxicity of minerals with special reference to arsenic.

Unit-III

Assessment of Nutritional status

BMI, biochemical assessment, basal and comprehensive metabolic panel, CBC, urine analyses, assessment of anemia, ROS assessment, GTT and glycosylated Hb, differential diagnosis of B12 and folate.

Food and drug interactions and Nutraceuticals

Definition and functional importance of nutriceuticals, interactive effects of alcohol, tobacco, anti- depressants and psychoactive drugs on (1) nutrient metabolism and assimilation, (2) appetite changes, (3) nutrient deficiency and malnutrition.

Core Paper-8P- Nutritional Biochemistry (Practical)
1 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.

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
- Nutrition Science by B. Sri Lakshmi New Age International (P) Limited, Publishers

IDC Paper:
BCM-H-IDC/BCM-MD-IDC
Biochemistry of Cell (Theory) 2 credits

Unit 1 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.

Unit 2 Amino acids and peptides
Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides
Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Unit 4 Nucleosides, nucleotides and nucleic acids
Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids
Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Unit 6 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.

Unit 7 Signalling molecules
Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca2+, NO. Brief account of their importance and role in signalling and signal transduction.

IDC paper: Biochemistry of Cell (Practicals) 1 credit

• General safety procedures in a laboratory. Use of auto pipettes. Making solutions and buffer preparation - acetate and tris buffers.
• Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
• Separation of amino acids by paper chromatography.
• Separation of sugars/bases by TLC and their identification.
• Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS

1. 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.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.

University of Calcutta

Syllabus for Three years B.Sc. (MULTIDISCIPLINARY)

(Under NEP)

BIOCHEMISTRY

2023

Index

COURSE STRUCTURE-MDC

	CC1/CC2		**Minor**	**IDC †**	**AEC**	**SEC**	**CVAC**	**Summer Internship**	**Total Credit**
Semester	8x4= 32	8x4= 32	6x4= 24	3x3=9	4x2= 8	3x4=12	4x2=8	1x3= 3	124
1	1x4= 4 **BCM-MD-CC1-1** 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 **BCM-MD-IDC1-1** 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4 **BCM-MD-SEC1-1/2/3** 3TH+1P	2x2=4		21
2	1x4= 4 **BCM-MD-CC2-2** 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 **BCM-MD-IDC1-1** 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4 **BCM-MD-SEC1-1/2/3** 3TH+1P	2x2=4		21
3	1x4= 4 **BCM-MD-CC3-3** (3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	1x4= 4 **BCM-MD-CC1-3** 3TH+1P/TU	1x3=3 **BCM-MD-IDC1-1** 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4 **BCM-MD-SEC1-1/2/3** 3TH+1P			21
4	2x4=8 **BCM-MD-CC4-4** **BCM-MD-CC5-4** 4x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU	1x4= 4 **BCM-MD-CC2-4** (3TH+1P/TU)		1x2= 2 2TH +0P/TU				22
5	2x4= 8 **BCM-MD-CC6-5** **BCM-MD-CC7-5** 2x(3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	2x4= 8 **BCM-MD-CC3-5** **BCM-MD-CC4-5** 2x(3TH+ 1P/TU						20
6	1x4= 4 **BCM-MD-CC8-6** (3TH + 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)	2x4= 8 **BCM-MD-CC5-6** **BCM-MD-CC6-6** 2x(3TH+ 1P/TU)						20
Credits	**8x4= 32**	**8x4= 32**	**6x4= 24**	**3x3= 9**	**4x2= 8**	**3x4= 12**	**4x2= 8**		**125+3 =128**
Marks	**8x100= 800**	**8x100= 800**	**6x100= 600**	**3x75= 225**	**4x50= 200**	**3x100= 300**	**4x50= 200**		**Total Marks =3200**

Marks= 25 marks per credit. Total credit=125+3 (for summer internship) = 128 Summer Internship: As mentioned in clause no. 8 (G)

† IDC paper (other than major and minor) has to be taken by a student once in 1st to 3rd semesters

Scheme for Biochemistry CC1/CC2 (TH & P) Curriculum (MDC)

SEMESTER	CC1/CC2	Paper Code	Course title	Credit
I	Core Paper 1	BCM-MD-CC1-1TH	Biomolecules	3
	Core Paper 1 Practical	BCM-MD-CC1-1P	Biomolecules	1
II	Core Paper 2	BCM-MD-CC2-2TH	General and Organic Chemistry	3
	Core Paper 2 Practical	BCM-MD-CC2-1P	General Organic Chemistry	1
III	Core Paper 3	BCM-MD-CC3-3TH	Enzymology	3
	Core Paper 3 Practical	BCM-MD-CC-3-3P	Enzymology	1
IV	Core Paper 4	BCM-MD-CC4-4TH	Nutritional Biochemistry	3
	Core Paper 4 Practical	BCM-MD-CC4-4P	Nutritional Biochemistry	1
	Core Paper 5	BCM-MD-CC5-4TH	Intermediary Metabolism	3
	Core Paper 5 Practical	BCM-MD-CC5-4P	Intermediary Metabolism	1
V	Core Paper 6	BCM-MD-CC6-5TH	Gene and Gene Expression	3
	Core Paper 6 Practical	BCM-MD-CC6-5P	Gene and Gene Expression	1
	Core Paper 7	BCM-MD-CC7-5TH	Cell Biology	3
	Core Paper 7 Practical	BCM-MD-CC7-5P	Cell Biology	1
VI	Core Paper 8	BCM-MD-CC8-6TH	Basic Microbiology	3
	Core Paper 8 Practical	BCM-MD-CC8-6P	Basic Microbiology	1

Subject- BIOCHEMISTRY

3 years Multidisciplinary courses

Detailed Syllabus

SEMESTER 1

Core Paper 1: Biomolecules (Theory) **3 Credit**

Unit-I

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).

Introduction to 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 (alanine, glutamic acid, lysine), Formol titration of glycine (only reaction and principle), reaction of amino acids ninhydrin and fluorescamine, separation and analysis of amino acids by paper & thin layer chromatography.

Unit-II

Introduction to peptides & proteins:

Peptide bond: Definition, structure and geometry of peptide bond, peptide bond lengths and configuration. Nature of stabilizing bonds - covalent and non-covalent forces. Example of biologically important peptide and its functions in brief (glutathione-peptide of non protein origin). 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 of 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, 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)

Unit-III

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. cofactors and pigments (preliminary ideas only).

Nucleic acids:

Nucleotides - structure and properties. Nucleic acid structure--- Watson-Crick model of DNA. Forms of DNA (A, B and Z DNA), Structure and function of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - DNA UV absorption, effect of acid and alkali on DNA and RNA. DNA melting, T_m value of DNA, hyperchromic shift of A_{260} of dsDNA during denaturation. Other functions of nucleotides - source of energy (nucleoside triphosphates), component of coenzymes (FAD, NAD^+), second messengers (cAMP, cGMP).

Reference books:

- 1. 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.
- 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. Harper's Illustrated Biochemistry(27th edition),ISBN-13:978-0071253017
- 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
- 5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin,
- T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

Core Paper 1P: Biomolecules (Theory) 1 Credit

List of Practical

1. Separation of amino acids by thin layer chromatography.
2. Qualitative test for carbohydrate.
3. Qualitative test for lipid.
4. Qualitative test for amino acids & proteins.
5. Assay of proteins using Lowry method, standard curve preparation.

SEMESTER 2

Core Paper 2: General and Organic Chemistry (Theory) 3 Credits

Unit I
Atomic Structure (Briefly)

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), Groundstate term symbols of atoms and ions (concept only).

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 H2 and O2 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; Effectof 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.

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

Reference Books

1. General &Inorganic Chemistry - R.P.Sarkar
2. Inorganic Chemistry - R.L.Dutta
3. New Concise Inorganic Chemistry - J.D.Lee
4. Inorganic Chemistry, Principles of Structure and Reactivity - J.E.Huheey, E.A.Keiter, & R.L.Keiter
5. Fundamental Concepts of inorganic Chemistry – A.K.Das

Unit 2

Basic Concept of Organic Chemistry (GOC):

Concept of hybridisation, inductive effect, resonance, hyperconjugation, Steric Effect, dipole moment, bond distance, and 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).

Aromaticity: Huckel's rules for aromaticity, antiaromaticity, nonaromaticity & homoaromaticity.

Type of reactions: Ionic, radical and pericyclic (concept only) reactions; Type of bond cleavage: heterolytic and, homolytic bond cleavage; Type of reagents: electrophile and nucleophile. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate.

Stereochemistry of Carbon Compounds:

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, flyingwedge and Newman formulae and their inter translations, Configuration: i) systems involving 1, 2, 3 stereocentres, 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. Conformation: 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.

General treatment of Reaction mechanism and kinetic study:

Reaction kinetics: transition state theory, rate constant and free energy of activation, free energy profiles for one step and two step reactions (concept only).

Nucleophilic substitution reactions: Substitution reactions involving S_N1, S_N2 and S_Ni mechanisms. Effectof substrate structure, nucleophiles (including ambident nucleophiles), solvent and leaving group; substitution involving neighboring group participations (NGP).

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

Aromatic Electrophilic and Nucleophilic substitution: Electrophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions) and activated nucleophilic substitution reactions.

Addition reactions to multiple bonds and carbonyl groups: Addition reactions to Carbon–carbon multiple bonds- Electrophilic additions mechanisms (concept only), dihydoxylation (1,2-diol), ozonolysis. Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$; oxidation of alcohols with PCC; oxidation of 1,2-diols using periodic acid and lead tetraacetate. Formation of acetal/ketal, Cannizzaro (including cross-Cannizzaro), aldol condensation (including directed and cross aldol condensation).

Organometallics and Heterocycles:

Organometallic chemistry: Grignard reactions (including abnormal behavior) and Corey-House synthesis (Gilman Catalyst, R_2CuLi).

Heterocycles: Structural aspects of five and six membered heterocycles containing hetero atoms (pyrrole, furan, thiophene and pyridine). Reactivity towards electrophilic and nucleophilic substitution (Concept only).

Reference Books

1. Organic Chemistry (vol.1&2) - I.L.Finar
2. A Guide to Organic Reaction Mechanism - P.Sykes
3. Organic Chemistry - P.Wothers, N.Greeves, J.Clayden, & S.Warren
4. Organic Chemistry - G.M.Loudon
5. Stereochemistry of Carbon Compounds - D.Nasipuri
6. Basic Stereochemistry of Organic Compounds - S.Sengupta
7. Stereochemistry of Organic Compounds - E.L.Eliel, & S.H.Wilen

Core Paper 2P: General and Organic Chemistry (Practical) 1 Credit

I. Physical characteristics (colour, odour, texture)
II. Solubility and classification (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)
III. Detection of special elements (N, Cl, S) by Lassaigne's tests.
IV. Detection of the following functional groups by systematic chemical tests: (aromatic amino ($–NH_2$), aromatic nitro ($– NO_2$), Amido ($–CONH_2$, including imide), 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.**

LABORATORY RECORDS

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

SEMESTER 3

Core Paper 3: ENZYMOLOGY (Theory) 3 credits

UNIT I

Enzyme and Enzyme Catalysis

a. Definition of enzymes, Nature of enzymes, protein and non-protein (ribozyme), apoenzyme and holoenzyme, differences between biocatalysts and chemical catalysts.

b. Cofactors: metal ions (Zn^{+2}, Mg^{+2}, Fe^{2+}) **[one example of enzyme using metal ion with reaction],** coenzymes, (NAD+, NADP+, HSCoA, FH4, cobalamin), prosthetic groups (FAD, TPP, PALPO, biotin) [**structures not needed, vitamin precursors, two examples of enzymes for each with reactions showing proper equation]** , co-substrate (NAD+)- one example with reaction.

c. IUBMB Classification of enzymes, Name & two examples of each class with reaction

d. Concept of active site, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis. proximity and orientation effect (orbital steering hypothesis to be mentioned), strain and distortion theory (example of Lysozyme/RNase catalyzed reaction).

e. Catalytic power and specificity of enzymes (stereospecifity and geometric specificity)

f. Mechanism of enzyme catalysis (basic concepts)
   i) acid- base catalysis (example- RNase A)
   ii) Metal ion catalysis: Metal activated enzymes (eg hexokinase) and metalloenzymes (eg carbonic anhydrase)
   iii) covalent catalysis (example- chymotrypsin)

UNIT II

Enzyme kinetics

a. Definition of Transition state, definition of Activation Energy, energy profile diagram for uncatalyzed and enzyme-catalyzed reactions, rate-determining step of a reaction, multistep reactions with energy profile diagram, binding energy, transition state analogs.

b. Concepts of rate, rate constant and order of a reaction, integrated form of rate expressions of first order reaction (derivation not needed, rate equation and graph needed), half-life period and its significance.

c. Concept of pre steady state and steady state, initial rate, maximum velocity (Vmax), Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions, association and dissociation constant, Michaelis-Menten equation (derivation and graphical representation), Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. Km and Vmax, Kcat and turnover number, Kcat/Km, enzyme activity, specific activity, katal, International Unit of enzyme activity. Numerical problems on Enzyme kinetics.

d. Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, time, metal ions on the activity of enzyme (Cu^{2+}, As^{2+}, Hg^{2+}, Pb^{2+}: one example of each) .

e. Bisubstrate reactions: Sequential reactions (Ordered and Random reactions with definition and example), Ping-pong reactions (definition and example of transamination reactions), differences between sequential and ping-pong reactions.

UNIT III

Enzyme Inhibition and Regulation of Enzyme Activity

a. Reversible inhibition (competitive, uncompetitive, non-competitive, mixed – one eg of each, Michaelis-Menten equation in the presence of respective inhibitor and effect of each inhibitor on K_M and V_{max} values.)

b. Irreversible inhibition- Mechanism based inhibitors (suicide substrate or suicide inhibitor), example of an antibiotic that acts as an inhibitor (Penicillin)

c. Control of activities of single enzymes: feedback inhibition

d. Properties of Allosteric enzyme (Aspartate transcarbamoylase) and its regulation, definition of M and K enzymes, Sequential and Symmetry Model.

e. Reversible covalent modification: phosphorylation and dephosphorylation (glycogen phosphorylase and glycogen synthase).

f. Proteolytic cleavage- zymogen (chymotrypsinogen and trypsinogen).

g. Isoenzymes - properties and physiological and clinical significance (lactate dehydrogenase and creatine kinase).

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 Paper 3P: ENZYMOLOGY (PRACTICAL) 1 credit

List of Practical

- Standard curve of p-nitrophenol.
- Assay of enzyme activity and specific activity of Alkanine Phosphatase.
- Effect of pH on the enzyme activity.
- Effect of temperature on the enzyme activity.
- Determination of Km and Vmax using Lineweaver-Burk graph.
- Enzyme inhibition - calculation of Ki for competitive inhibition

SEMESTER 4

Core Paper 4: Nutritional Biochemistry (Theory) 3 Credits

Unit-I

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 (RDA) for different age groups.

Dietary carbohydrates, lipids, proteins and health

RDA, sources and functions and storage of carbohydrates, proteins and lipids in human health, essential and non-essential amino acids and fatty acids, excess, toxicity, imbalance and deficiency of amino acids and fatty acids, dietary importance/implications of MUFA, PUFA, SFA, omega fatty acids with omega3/omega 6 ratio, phospholipids, cholesterol, triglycerides, saturated fats and oils, combined ratios of n6 and n3, lipotropic factors, amino acid supplementation, amino acid pool, amino acid availability, antagonism, NPU, BV, nitrogen balance, nitrogen cycle, protein calorie malnutrition - Kwashiorkar and Marasmus.

Dietary fibres and health

Role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Unit-II

Vitamins

RDA, sources, storage, adsorption, distribution, metabolism and excretion (ADME) of fat- and water-soluble vitamins, functional role of vitamins (vitamin A as an antioxidant, in visual cycle, dermatology and immunity, vitamin B6 in pyridoxal phosphate formation, niacin-metabolic interrelation between tryptophan, niacin and NAD/ NADP, vitamin C as cofactor in amino acid modifications, extra-skeletal role of Vitamin D and its effect on bone physiology, vitamin E as an antioxidant, vitamin K in gamma carboxylation and blood coagulation, hypervitaminosis and deficiency of vitamins with deficiency symptoms and treatment. A correlation of Vitamin B12 and folate mentioning dietary source, RDA, absorption, metabolic role and biochemical basis for deficiency symptoms.

Minerals

RDA, sources, storage, digestion, absorption, utilization, transport, excretion, balance, deficiency and distribution in human body for calcium, phosphorus, iron, iodine, fluoride, Mg, Cu, Zn, Se, manganese, chromium, molybdenum, calcium: phosphorus ratio, role of iron in prevention of anemia, iodine cycle, toxicity of minerals with special reference to arsenic.

Unit-III

Assessment of Nutritional status

BMI, biochemical assessment, basal and comprehensive metabolic panel, CBC, urine analyses, assessment of anemia, ROS assessment, GTT and glycosylated Hb, differential diagnosis of B12 and folate.

Food and drug interactions and Nutraceuticals

Definition and functional importance of nutriceuticals, interactive effects of alcohol, tobacco, anti-depressants and psychoactive drugs on (1) nutrient metabolism and assimilation, (2) appetite changes, (3) nutrient deficiency and malnutrition.

Paper-4P- Nutritional Biochemistry (Practical) 1 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.

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
- Nutrition Science by B. Sri Lakshmi New Age International (P) Limited, Publishers

Core Paper 5- Intermediary Metabolism (Theory) 3 credits

1 Basic concepts and design of metabolism
The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

2 Glycolysis and gluconeogenesis
Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

3 The citric acid cycle
Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

4 Oxidative phosphorylation
The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

5 Photosynthesis, Calvin cycle and pentose phosphate pathway
The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pathway, importance and regulation.

6 Glycogen metabolism
Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

7. Fatty acid synthesis and degradation
TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

8. Amino acid catabolism and anabolism
Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.

9 Nucleotide metabolism
Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by Feedback inhibition, degradation and excretion.

10 Integration of metabolism
Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel To brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.

Core Paper 5P: Intermediary Metabolism (Practicals) Credit: 1

1. Alcohol fermentation by yeast.
2. H2S production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS

1. Biochemistry (2012) 7th ed., Campbell, M.K. and Farrel, S.O. Brooks/Cole, Cengage Learning (Boston), ISBN: 13:978-1-111-42564-7.

SEMESTER 5

Core Paper 6- Gene and Gene Expression (Theory) 3 credits

GENE ORGANIZATION, EXPRESSION AND REGULATION (THEORY)

1 Structure of genes and chromosomes
Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

2 Replication of genomes
General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and teleomeres in linear chromosomes. Replication of RNA genomes.

3 Recombination of DNA
Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

4 Gene mutations and repair
Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

5 Transcription of genes
General features of gene transcription, procaryotic and eukaryotic RNA polymerases, Stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

6 RNA processing
Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, Ribosomal and tRNA processing.

7 Protein synthesis
Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

8 Regulation of gene expression
Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

Core Paper 6P- Gene, Gene Expression (Practical) 1 Credit

1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A260/A280 ratio to distinguish between them.
2. Isolation of plasmid DNA
3. Isolation of chromosomal DNA from *E. coli.*
4. Isolation of total RNA from yeast cells.

SUGGESTED READINGS

- 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.
- 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 SivaramaSastri, G Padmanavan and C. Subramanyam
- Stryer's Biochemistry

Core Paper 7- Cell biology (Theory) 3 credits

Unit-I

Cell-The unit of life- Cell Theory and Cells as basic functional unit of living body, cellular classification, basic structures of Prokaryotic (Archaea and Eubacteria) and eukaryotic cell (Animal and Plant cells), differences between Prokaryotes and Eukaryotes.

Ultra-structure and composition of Plasma membrane: Fluid mosaic model.

Structure and functions of different cell organelles: Nucleus (nuclear envelope, nuclear pore complex and Nucleolus), Major events occurring in the nucleus; ER structure & function (Brief), Organization of Golgi apparatus and function (Brief), Lysosome, mitochondria (semi-autonomous nature), chloroplasts and peroxisomes.

Unit-II

Cell wall, cytoskeleton and extracellular matrix:

Prokaryotic cell wall and Cell wall in Plant, Type, structure and functions of cytoskeleton; Accessory proteins of microfilament & microtubule, brief introduction on Cell-Cell Interactions and Cell-Matrix Interactions.

Cell cycle: Definition and phases of Eukaryotic cell cycle (Schematic only), importance of cell cycle checkpoints. Cell division- a basic understanding of mitosis and meiosis (Schematic description), Definition of Apoptosis.

Cell signaling (Preliminary concept)

Scheme of a generalized cell signaling transduction pathway and its importance, Types of signaling molecules and receptors (Classification and Example only).

Core Paper 7P- Cell Biology (Practical) 1 Credit

List of Practical

1. Visualization of animal (Squamous epithelium) and plant (Onion) cells by methylene blue.
2. Micrographs of different cell components
3. Study of mitosis and meiosis from permanent slides (dry lab).

Reference Books:

- Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6 edition. John Wiley & Sons. Inc.

- Alberts, B., Johnson,A., Lewis, J., and Enlarge, M. 2008 Molecular Biology of the Cell. 5th ed., Garland Science (Princeton),
- Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J. 2012. Molecular Cell Biology. 7th ed., W.H. Freeman & Company (New York),
- 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.

SEMESTER 6

Core Paper 8- Basic Microbiology (Theory) 3 Credits

1 History of Development of Microbiology:

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease, Development of various micobiological techniques and golden era of microbiology, Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

2 Diversity of Microbial world:

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms. General characteristics of different groups: acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

3 Bacteria:

An account of typical eubacteria, chlamydiae & rickettsiae (obligate intracellular parasites), mycoplasma, and archaebacteria (extremophiles). Applications of bacteria in industry, environment and food.

4 Viruses, viroids and prions

An introduction to viruses with special reference to the structure and replication of the following: T4 and λ phage, lytic and lysogenic cycles, Poxvirus, Poliovirus, HIV.

5 Algae:

History of phycology; General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Applications of Algae in agriculture, industry, environment and food.

6 Fungi:

Historical developments in the field of Mycology, significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic Importance of Fungi in Agriculture, environment, Industry, medicine, food, biodeterioration, mycotoxins

7 Protozoa:

General characteristics with special reference to Amoeba

Core Paper 8P- Basic Microbiology (Practical) 1 Credit

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.
7. Estimation of CFU count.

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W M.T.Brown Publishers.
2. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company

Scheme for Minor Curriculum (Semester 3-Semester 6

Semester	Course Name	**Paper Code**	Course Detail	Credits
III	Paper 1	BCM-MD-CC1-1TH	Biomolecules	3
	Paper 1 Practical	BCM-MD-CC1-1P	Biomolecules	1
IV	Paper 2	BCM-MD-CC2-2TH	General and Organic Chemistry	3
	Paper 2 Practical	BCM-MD-CC2-1P	General Organic Chemistry	1
V	Paper 3	BCM-MD-CC3-3TH	Enzymology	3
	Paper 3 Practical	BCM-MD-CC-3-3P	Enzymology	1
	Paper 4	BCM-MD-CC4-4TH	Nutritional Biochemistry	3
	Paper 4 Practical	BCM-MD-CC4-4P	Nutritional Biochemistry	1
VI	Paper 5	BCM-MD-CC5-4TH	Intermediary Metabolism	3
	Paper 5 Practical	BCM-MD-CC5-4P	Intermediary Metabolism	1
	Paper 6	BCM-MD-CC6-5TH	Gene and Gene Expression	3
	Paper 6 Practical	BCM-MD-CC6-5P	Gene and Gene Expression	1

Detailed Minor Syllabus

SEMESTER 3

Minor Paper 1: Biomolecules (Theory) 3 Credit

Unit-I

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).

Introduction to 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 (alanine, glutamic acid, lysine), Formol titration of glycine (only reaction and principle), reaction of amino acids ninhydrin and fluorescamine, separation and analysis of amino acids by paper & thin layer chromatography.

Unit-II

Introduction to peptides & proteins:

Peptide bond: Definition, structure and geometry of peptide bond, peptide bond lengths and configuration. Nature of stabilizing bonds - covalent and non-covalent forces. Example of biologically important peptide and its functions in brief (glutathione-peptide of non protein origin). 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 of 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, 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)

Unit-III

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. cofactors and pigments (preliminary ideas only).

Nucleic acids:

Nucleotides - structure and properties. Nucleic acid structure--- Watson-Crick model of DNA. Forms of DNA (A, B and Z DNA), Structure and function of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - DNA UV absorption, effect of acid and alkali on DNA and RNA. DNA melting, T_m value of DNA, hyperchromic shift of A_{260} of dsDNA during denaturation. Other functions of nucleotides - source of energy (nucleoside triphosphates), component of coenzymes (FAD, NAD^+), second messengers (cAMP, cGMP).

Reference books:

- 1. 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.
- 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. Harper's Illustrated Biochemistry(27th edition),ISBN-13:978-0071253017
- 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
- 5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin,
- T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

Biomolecules (Practical) **1 Credit**

List of Practical

6. Separation of amino acids by thin layer chromatography.
7. Qualitative test for carbohydrate.
8. Qualitative test for lipid.
9. Qualitative test for amino acids & proteins.
10. Assay of proteins using Lowry method, standard curve preparation.

SEMESTER 4

Minor Paper 2: General and Organic Chemistry (Theory) (m1) 3 Credits

Unit I
Atomic Structure (Briefly)

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), Groundstate term symbols of atoms and ions (concept only).

Intermolecular forces

e. 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.

f. 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 H2 and O2 molecular orbitals , sigma and pi bonds, multiple bonding. Concept of Bond order, bond length, bond strength, bond energy.

g. Weak Chemical Forces

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

h. 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.

Radioactivity and the applications of radioactive isotopes

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

Reference Books

6. General &Inorganic Chemistry - R.P.Sarkar
7. Inorganic Chemistry - R.L.Dutta
8. New Concise Inorganic Chemistry - J.D.Lee
9. Inorganic Chemistry, Principles of Structure and Reactivity - J.E.Huheey, E.A.Keiter, & R.L.Keiter
10. Fundamental Concepts of inorganic Chemistry – A.K.Das

Unit 2

Basic Concept of Organic Chemistry (GOC):

Concept of hybridisation, inductive effect, resonance, hyperconjugation, Steric Effect, dipole moment, bond distance, and 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).

Aromaticity: Huckel's rules for aromaticity, antiaromaticity, nonaromaticity & homoaromaticity.

Type of reactions: Ionic, radical and pericyclic (concept only) reactions; Type of bond cleavage: heterolytic and, homolytic bond cleavage; Type of reagents: electrophile and nucleophile. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate.

Stereochemistry of Carbon Compounds:

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, flyingwedge and Newman formulae and their inter translations, Configuration: i) systems involving 1, 2, 3 stereocentres, 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. Conformation: 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.

General treatment of Reaction mechanism and kinetic study:

Reaction kinetics: transition state theory, rate constant and free energy of activation, free energy profiles for one step and two step reactions (concept only).

Nucleophilic substitution reactions: Substitution reactions involving S_N1, S_N2 and S_Ni mechanisms. Effectof substrate structure, nucleophiles (including ambident nucleophiles), solvent and leaving

group; substitution involving neighboring group participations (NGP).

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

Aromatic Electrophilic and Nucleophilic substitution: Electrophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions) and activated nucleophilic substitution reactions.

Addition reactions to multiple bonds and carbonyl groups: Addition reactions to Carbon–carbon multiple bonds- Electrophilic additions mechanisms (concept only), dihydoxylation (1,2-diol), ozonolysis. Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$; oxidation of alcohols with PCC; oxidation of 1,2-diols using periodic acid and lead tetraacetate. Formation of acetal/ketal, Cannizzaro (including cross-Cannizzaro), aldol condensation (including directed and cross aldol condensation).

Organometallics and Heterocycles:

Organometallic chemistry: Grignard reactions (including abnormal behavior) and Corey-House synthesis (Gilman Catalyst, R_2CuLi).

Heterocycles: Structural aspects of five and six membered heterocycles containing hetero atoms (pyrrole, furan, thiophene and pyridine). Reactivity towards electrophilic and nucleophilic substitution (Concept only).

Reference Books

8. Organic Chemistry (vol.1&2) - I.L.Finar
9. A Guide to Organic Reaction Mechanism - P.Sykes
10. Organic Chemistry - P.Wothers, N.Greeves, J.Clayden, & S.Warren
11. Organic Chemistry - G.M.Loudon
12. Stereochemistry of Carbon Compounds - D.Nasipuri
13. Basic Stereochemistry of Organic Compounds - S.Sengupta
14. Stereochemistry of Organic Compounds - E.L.Eliel, & S.H.Wilen

Minor Paper 2P: General and Organic Chemistry (Practical) 1 Credit

V. Physical characteristics (colour, odour, texture)
VI. Solubility and classification (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)
VII. Detection of special elements (N, Cl, S) by Lassaigne's tests.
VIII. Detection of the following functional groups by systematic chemical tests: (aromatic amino ($–NH_2$), aromatic nitro ($– NO_2$), Amido ($–CONH_2$, including imide), 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.**

LABORATORY RECORDS

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:

(iii) Advanced Practical Chemistry – Subhas Ch. Das
(iv) Handbook of Practical Chemistry – University of Calcutta

SEMESTER 5

Minor Paper 3: ENZYMOLOGY (Theory) 3 credits

UNIT I

Enzyme and Enzyme Catalysis

g. Definition of enzymes, Nature of enzymes, protein and non-protein (ribozyme), apoenzyme and holoenzyme, differences between biocatalysts and chemical catalysts.

h. Cofactors: metal ions (Zn^{+2}, Mg^{+2}, Fe^{2+}) **[one example of enzyme using metal ion with reaction],** coenzymes, (NAD+, NADP+, HSCoA, FH4, cobalamin), prosthetic groups (FAD, TPP, PALPO, biotin) [**structures not needed, vitamin precursors, two examples of enzymes for each with reactions showing proper equation]** , co-substrate (NAD+)- one example with reaction.

i. IUBMB Classification of enzymes, Name & two examples of each class with reaction

j. Concept of active site, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis. proximity and orientation effect (orbital steering hypothesis to be mentioned), strain and distortion theory (example of Lysozyme/RNase catalyzed reaction).

k. Catalytic power and specificity of enzymes (stereospecifity and geometric specificity)

l. Mechanism of enzyme catalysis (basic concepts)
   i) acid- base catalysis (example- RNase A)
   ii) Metal ion catalysis: Metal activated enzymes (eg hexokinase) and metalloenzymes (eg carbonic anhydrase)
   iii) covalent catalysis (example- chymotrypsin)

UNIT II

Enzyme kinetics

f. Definition of Transition state, definition of Activation Energy, energy profile diagram for uncatalyzed and enzyme-catalyzed reactions, rate-determining step of a reaction, multistep reactions with energy profile diagram, binding energy, transition state analogs.

g. Concepts of rate, rate constant and order of a reaction, integrated form of rate expressions of first order reaction (derivation not needed, rate equation and graph needed), half-life period and its significance.

h. Concept of pre steady state and steady state, initial rate, maximum velocity (Vmax), Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions, association and dissociation constant, Michaelis-Menten equation (derivation and graphical representation), Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. Km and Vmax, Kcat and turnover number, Kcat/Km, enzyme activity, specific activity, katal, International Unit of enzyme activity. Numerical problems on Enzyme kinetics.

i. Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, time, metal ions on the activity of enzyme (Cu^{2+}, As^{2+}, Hg^{2+}, Pb^{2+}: one example of each) .

j. Bisubstrate reactions: Sequential reactions (Ordered and Random reactions with definition and example), Ping-pong reactions (definition and example of transamination reactions), differences between sequential and ping-pong reactions.

UNIT III

Enzyme Inhibition and Regulation of Enzyme Activity

h. Reversible inhibition (competitive, uncompetitive, non-competitive, mixed – one eg of each, Michaelis-Menten equation in the presence of respective inhibitor and effect of each inhibitor on K_M and V_{max} values.)

i. Irreversible inhibition- Mechanism based inhibitors (suicide substrate or suicide inhibitor), example of an antibiotic that acts as an inhibitor (Penicillin)

j. Control of activities of single enzymes: feedback inhibition

k. Properties of Allosteric enzyme (Aspartate transcarbamoylase) and its regulation, definition of M and K enzymes, Sequential and Symmetry Model.

l. Reversible covalent modification: phosphorylation and dephosphorylation (glycogen phosphorylase and glycogen synthase).

m. Proteolytic cleavage- zymogen (chymotrypsinogen and trypsinogen).

n. Isoenzymes - properties and physiological and clinical significance (lactate dehydrogenase and creatine kinase).

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 paper 3P: ENZYMOLOGY (PRACTICAL) 1 credit

List of Practical

- Standard curve of p-nitrophenol.
- Assay of enzyme activity and specific activity of Alkanine Phosphatase.
- Effect of pH on the enzyme activity.
- Effect of temperature on the enzyme activity.
- Determination of Km and Vmax using Lineweaver-Burk graph.
- Enzyme inhibition - calculation of Ki for competitive inhibition

Minor Paper 4: Nutritional Biochemistry (Theory) 3 Credits

Unit-I
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 (RDA) for different age groups.

Dietary carbohydrates, lipids, proteins and health

RDA, sources and functions and storage of carbohydrates, proteins and lipids in human health, essential and non-essential amino acids and fatty acids, excess, toxicity, imbalance and deficiency of amino acids and fatty acids, dietary importance/implications of MUFA, PUFA, SFA, omega fatty acids with omega3/omega 6 ratio, phospholipids, cholesterol, triglycerides, saturated fats and oils, combined ratios of n6 and n3, lipotropic factors, amino acid supplementation, amino acid pool, amino acid availability, antagonism, NPU, BV, nitrogen balance, nitrogen cycle, protein calorie malnutrition - Kwashiorkar and Marasmus.

Dietary fibres and health

Role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Unit-II

Vitamins

RDA, sources, storage, adsorption, distribution, metabolism and excretion (ADME) of fat- and water-soluble vitamins, functional role of vitamins (vitamin A as an antioxidant, in visual cycle, dermatology and immunity, vitamin B6 in pyridoxal phosphate formation, niacin-metabolic interrelation between tryptophan, niacin and NAD/ NADP, vitamin C as cofactor in amino acid modifications, extra-skeletal role of Vitamin D and its effect on bone physiology, vitamin E as an antioxidant, vitamin K in gamma carboxylation and blood coagulation, hypervitaminosis and deficiency of vitamins with deficiency symptoms and treatment. A correlation of Vitamin B12 and folate mentioning dietary source, RDA, absorption, metabolic role and biochemical basis for deficiency symptoms.

Minerals

RDA, sources, storage, digestion, absorption, utilization, transport, excretion, balance, deficiency and distribution in human body for calcium, phosphorus, iron, iodine, fluoride, Mg, Cu, Zn, Se, manganese, chromium, molybdenum, calcium: phosphorus ratio, role of iron in prevention of anemia, iodine cycle, toxicity of minerals with special reference to arsenic.

Unit-III

Assessment of Nutritional status

BMI, biochemical assessment, basal and comprehensive metabolic panel, CBC, urine analyses, assessment of anemia, ROS assessment, GTT and glycosylated Hb, differential diagnosis of B12 and folate.

Food and drug interactions and Nutraceuticals

Definition and functional importance of nutriceuticals, interactive effects of alcohol, tobacco, anti-depressants and psychoactive drugs on (1) nutrient metabolism and assimilation, (2) appetite changes, (3) nutrient deficiency and malnutrition.

Minor Paper-4P- Nutritional Biochemistry (Practical) 1 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.

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
- Nutrition Science by B. Sri Lakshmi New Age International (P) Limited, Publishers

SEMESTER 6

Paper 5- Intermediary Metabolism (Theory) 3 credits

1 Basic concepts and design of metabolism
The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

2 Glycolysis and gluconeogenesis
Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

3 The citric acid cycle
Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

4 Oxidative phosphorylation
The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

5 Photosynthesis, Calvin cycle and pentose phosphate pathway
The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pathway, importance and regulation.

6 Glycogen metabolism
Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

7. Fatty acid synthesis and degradation
TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

8. Amino acid catabolism and anabolism
Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.

9 Nucleotide metabolism
Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by Feedback inhibition, degradation and excretion.

10 Integration of metabolism
Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel To brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.

Core Paper 5P: Intermediary Metabolism (Practicals) Credit: 1

1. Alcohol fermentation by yeast.
2. H2S production, indole production and ammonia production by bacteria.
3. Urea estimation.

4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS

1. Biochemistry (2012) 7th ed., Campbell, M.K. and Farrel, S.O. Brooks/Cole, Cengage Learning (Boston), ISBN: 13:978-1-111-42564-7.

Paper 6- Gene and Gene Expression (Theory) 3 credits

1 Structure of genes and chromosomes

Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

2 Replication of genomes

General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and teleomeres in linear chromosomes. Replication of RNA genomes.

3 Recombination of DNA

Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

4 Gene mutations and repair

Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

5 Transcription of genes

General features of gene transcription, procaryotic and eukaryotic RNA polymerases, Stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

6 RNA processing

Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, Ribosomal and tRNA processing.

7 Protein synthesis

Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

8 Regulation of gene expression

Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

Core Paper 6P- Gene, Gene Expression (Practical) 1 Credit

1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A260/A280 ratio to distinguish between them.
2. Isolation of plasmid DNA

3. Isolation of chromosomal DNA from *E. coli.*
4. Isolation of total RNA from yeast cells.

SUGGESTED READINGS

- 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.
- 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 SivaramaSastri, G Padmanavan and C. Subramanyam
- Stryer's Biochemistry

Skill Enhancement courses (SEC) (MDC)

SEMESTER	SEC	Paper Code	Course title	Credit
I/II/III	Skill Enhancement course 1	BCM-MD-SEC1-1/2/3 TH	Tools and Techniques in Biochemistry	3
	Skill Enhancement course 1- Practical	BCM-MD-SEC1-1/2/3 P	Tools and Techniques in Biochemistry	1

Skill Enhancement courses (SEC) (MDC) detailed syllabus

Semester 1/2/3

Tools and Techniques in Biochemistry (Theory) 3 Credits

Unit I

Basic Lab Practices and Preparation of Solutions

Safety practices in the laboratory, preparation and storage of solutions, concepts of solution concentration and storing solutions: Standard solutions, molar, normal, molal, formal and percent strengths, quantitative transfer of liquids.

Special chemical requirement of biomolecules, factors affecting analyte structure and stability,pH, temperature and solvent polarity, buffering systems used in biochemistry, concept ofcolligative properties (no derivations), osmolarity, diffusion of solutes in solution.

Basic Instruments and techniques: Working principles, basic operation and application ofweighing balance, pH meter, autoclave, laminar air flow, Water Baths, CO2 Incubators, Shaking Incubators, Hot Air Ovens, Bio-Safety Hoods.

Pipettes and MilliQ water system.Principle of asepsis and sterilization technique.

Unit-II

Microscopy – Working principles, basic operation and applicationofLight and phase contrast microscope.

Centrifugation techniques: Sedimentation (Sedimentation coefficient, Svedberg unit), Centrifugation: Working principles, basic operation and application ofmicro-centrifuge,ultracentrifuge and density gradient centrifugation, applications (isolation of cellcomponents).

Different Biophysical Techniques

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.

SEC 1P: Tools and Techniques in Biochemistry (Practical) 1 Credit

List of Practical

1. Safety measure in laboratories, use and calibration of pipettes
2. Preparation of normal, molar and percent solutions
3. Standardization of NaOH and acetic acid solutions
4. Concept of pH and preparation of buffers, pH metric titration of a weak acid with a strong base.
5. Determination of extinction coefficient of different BSA solutions by spectrophotometer.

Reference Books:

- Physical Chemistry - P. C. Rakshit
- Lehninger Principles of Biochemistry - Nelson & Cox Text Book of Physical Chemistry - K. L. Kapoor
- Physical Chemistry-Hrishikesh Chatterjee
- Techniques and Methods in Biology - K. L. Ghatak
- Physical Biochemistry: Principles and Applications - D. Sheehan,
- Physical Biochemistry: Applications to Biochemistry and Molecular Biology – D. Freifelder
- An Introduction to Practical Biochemistry – D. T. Plummer
- Molecular Spectroscopy - C. N. Banwell&McCash Organic Spectroscopy - William Kemp

IDC Paper:
BCM-H-IDC/BCM-MD-IDC
Biochemistry of Cell (Theory) 2 credits

Unit 1 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.

Unit 2 Amino acids and peptides
Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides
Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Unit 4 Nucleosides, nucleotides and nucleic acids
Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids
Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Unit 6 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.

Unit 7 Signalling molecules
Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca2+, NO. Brief account of their importance and role in signalling and signal transduction.

IDC paper: Biochemistry of Cell (Practicals) 1 credit

• General safety procedures in a laboratory. Use of auto pipettes. Making solutions and buffer preparation - acetate and tris buffers.
• Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
• Separation of amino acids by paper chromatography.
• Separation of sugars/bases by TLC and their identification.
• Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS
1. 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.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.