Telephone No. 2419677/2419361
Fax: 0821-2419363/2419301

e-mail : registrar@uni-mysore.ac.in
www.uni-mysore.ac.in

UNIVERSITY OF MYSORE

Estd. 1916

VishwavidyanilayaKaryasoudha
Crawford Hall, Mysuru- 570 005

No.AC2(S)/164/2021-22

Dated: 27-01-2022

Notification

Sub:- Revision of the Existing Syllabus of M.Sc and Ph.D course work Biochemistry (PG) with effective from the Academic year 2021-22.

Ref:-
1. Decision of Board of Studies in Biochemistry (PG) meeting held on 25-11-2021.
2. Decision of the Faculty of Science & Technology Meeting held on 20-12-2021.
3. Decision of the Academic Council meeting held on 23-12-2021.

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The Board of studies in Biochemistry (PG) which met on 25-11-2021 has recommended to revise the Existing Syllabus both M.Sc and Ph.D course work of Biochemistry Programme to effective from the Academic year 2021-22.

The Faculty of Science & Technology and Academic Council at their meetings held on 20-12-2021 and 23-12-2021 respectively have also approved the above said proposal and it is hereby notified.

The syllabus is annexed herewith and the contents may be downloaded from the University Website i.e., www.uni-mysore.ac.in.

DRAFT APPROVED BY THE REGISTRAR

27/1

Deputy Registrar (Academic)
University of Mysore
Mysore-570 005

Deputy Registrar(Academic)

To:-

1. The Registrar (Evaluation), University of Mysore, Mysuru.
2. The Chairman, BOS/DOS, in Biochemistry (PG), Manasagangothri, Mysore.
3. The Dean, Faculty of Science & Technology, DoS in Earth Science, MGM.
4. The Director, Distance Education Programme, Moulya Bhavan, Manasagangotri, Mysuru.
5. The Director, PMEB, Manasagangothri, Mysore.
6. Director, College Development Council , Manasagangothri, Mysore.
7. The Deputy Registrar/Assistant Registrar/Superintendent, Administrative Branch and Examination Branch, University of Mysore, Mysuru.
8. The PA to Vice-Chancellor/ Registrar/ Registrar (Evaluation), University of Mysore, Mysuru.
9. Office Copy.

Department of Studies in Biochemistry

University of Mysore

Manasagangothri, Mysore

Biochemistry Syllabus

(2021-November)

Department of Studies in Biochemistry

University of Mysore

Manasagangotri

Choice Based Credit System (2021 November)

Department of Studies in Biochemistry offer two programmes

1. **M.Sc., in the subject Biochemistry**
2. **Ph.D. in the subject Biochemistry**

M.Sc. in the subject Biochemistry

Programme objectives

The main objectives of this M.Sc., programme is to provide strong foundation in the subject Biochemistry to become

- Teaching faculties in Academic Institutions.
- Researchers in research institutions or industries.
- Entrepreneur to start their own company.

Programme Outcomes

The M.Sc., programme in Biochemistry is highly sought programme among life sciences in the University. On successful completion of this programme each student will:

- Have a strong foundation in understanding the basic biochemical reactions that occurs in both prokaryotic and eukaryotic systems. Further the student will be able to learn cutting edge technology in the field of cell biology, molecular biology, microbiology, immunology and medicinal biology.

- Develop practical skills along with their theory components, which will help in their research programme both in academic institutions and in R & D programmes of industries.
- Inculcate skills for teaching in academic institutions for undergraduate and postgraduate students.
- Develop confidence in taking competitive examination in the field of life science both in India and abroad so that they can pursue higher education.

Pedagogies employed in the M.Sc. Degree programme

- Class room teaching will be using black board and chalk, power point presentation and information and communications technology.
- One on one interaction or with small student numbers during tutorial classes.
- Each student performs experiments as per the protocol in practical classes.
- Student seminar/research paper presentation in each semester.
- Project work on a small research problem.
- Literature review in the form of Dissertation.
- Invited talks from eminent scientists.

Syllabus for M.Sc. Degree in Biochemistry

The Choice Based Credit System (CBCS) comprises courses in the form of Hard Core, Soft Core for Biochemistry Students and Open Elective course for students other than Biochemistry. Following shall be the minimum and maximum courses per semester.

The credit pattern is Lecture (L); Tutorial (T); Practical (P); (L:T:P) Pattern.

Lecture: One hour session of theory class per week in a semester is 1 credit.

Tutorial and Practical: Two hour session of tutorial or practical per week in a semester is 1 credit.

One semester period is 16 weeks of teaching and learning.

Duration of semester is 20 weeks that include semester end examinations.

Credit Pattern of courses:

Hard Core: 3 – 6 Credits

Soft Core: 2 – 4 Credits

Open elective: 4 Credits

Credit Distribution of courses:

Course Type	Credits
Hard Core	**Minimum Credits - 42 and Maximum Credits - 52**
Soft Core	**Minimum Credits – 16**
Open Elective/SWAYAM/MOOC	**Minimum Credits – 4**

- A Candidate can enroll for a minimum of 18 Credits course per semester and maximum of 24 Credits course per semester inclusive of Open Elective earned from the other Departments /SWAYAM/MOOC as per UGC regulations.
- A Candidate has to earn a minimum of 76 Credits for successful completion of a Masters degree.
- A minimum 76 Credits and additional 18 Credits (76 + 18 = 94 Credits) shall acquire add on Proficiency Diploma.

Continuous Assessment Pattern for each course (70:30) pattern:

Continuous Assessment	Time Duration	Marks		C1+C2 minimum 30%, and a final aggregate of 40% to declare pass in a semester
		Max	Min	
C1	1 week to 8 weeks	15	4.5	
C2	9 week to 16 weeks	15	4.5	
C3	Complete 16 weeks	70	21	

Credit Distribution of courses

Hard Core- 52 Credits distributed as 10 – 15 credits in a semester

Soft Core- 36 Credits distributed as 8 – 14 credits in a semester

Open Elective-12 Credits distributed as 4 credits in a semester from II semester onwards

Semester	Hard Core	Soft Core	OE/ SWAYAM/ MOOC	Total Credits
I	6 + 3 + 3 + 3 (15)	3 + 3 + 3 (9)	0	24 + 0
II	6 + 3 + 3 (12)	3 + 3+2 (8)	4	20 + 4
III	6 + 3 + 3+3 (15)	3 + 2 (5)	4	20 + 4
IV	4 + 3 + 3 (10)	4+ 4 + 3 +3 (14)	0	24 + 0
Total	52	36	8	88 + 08

The minimum course credit is relaxed for those who accumulated maximum credit in the previous semesters

Eligibility for admission:

Students of Bachelors of Science degree from any UGC recognized Universities in life science subjects **with Chemistry or Biochemistry** as major subjects are eligible. Students from Foreign National degree will apply through equivalence committee. Minimum percentage of marks is as prescribed by the University of Mysore regulations for admission.

I Semester

Sl. No.	Code	Title of the course	Course Type	Credit pattern			Total Credits
				L	T	P	
1		Biomolecules	HC	3	0	0	3
2		Bioorganic and Bioinorganic Chemistry	HC	3	0	0	3
3		Biochemical Techniques	HC	3	0	0	3
4		Practical-1: Biochemical Techniques.	HC	0	0	6	6
5		Biophysical Techniques	SC	3	0	0	3
6		Plant Biochemistry	SC	3	0	0	3
7		Membrane Biology	SC	3	0	0	3

II Semester

Sl. No.	Code	Title of the course	Course Type	Credit pattern			Total Credits
				L	T	P	
1		Enzymology	HC	3	0	0	3
2		Metabolism of fuel molecules	HC	3	0	0	3
3		Practical- 2: Experiments in Enzymology and fuel molecules.	HC	0	0	6	6
4		Physiology	SC	3	0	0	3
5		Nutritional Biochemistry	SC	3	0	0	3
6		Biostatistics	SC	2	0	0	2
8		Clinical Diagnosis in Health and Diseases	OE	3	1	0	4

III Semester

Sl. No.	Code	Title of the course	Course Type	Credit pattern			Total Credits
				L	T	P	
1		Molecular Biology	HC	3	0	0	3
2		Metabolism of Nitrogenous Compounds	HC	3	0	0	3
3		Immunology	HC	3	0	0	3
4		Practical-3: Experiments in Immunology and metabolism.	HC	0	0	6	6
5		Clinical Biochemistry	SC	3	0	0	3
6		Genomics and Proteomics	SC	2	0	0	2
7		Fundamentals of Biochemistry	OE	3	1	0	4

IV Semester

Sl. No.	Code	Title of the course	Course Type	Credit pattern			Total Credits
				L	T	P	
1		Cell Biology	HC	3	0	0	3
		Gene Regulation	HC	3	0	0	3
2		Practical-4: Experiments in Molecular Biology.	HC	0	0	2	4
3		Project Work	SC	0	0	6	4
4		Seminar	SC	0	4	0	4
5		Genetic Engineering	SC	3	0	0	3
6		Biotechnology	SC	3	0	0	3
7		Clinical Diagnosis in Health and Disease	OE	3	1	0	4

Course Design: Hard core and soft core papers are either 3 credits or 2 credits. The open elective paper is for 4 credits. Each course is divided into four units. With 3 and 4 credits open elective course; each unit carry 12 hours of lecturing and in 2 credit course each unit carry 8 hours of lecturing.

I Semester Biochemistry

Courses - Hard Cores

Biomolecules – 3 credits 48h

Objectives are:

- To study various biomolecules of a cell.
- To study structural characterization of biomolecules

Course outcome, the student will:

- Understand structure and classification of carbohydrates, amino acids, lipids proteins and nucleic acids.
- Understand glycobiology, protein folding, forces affecting protein folding.
- Understand the determination of amino acid composition, sequencing of DNA.

Unit- 1

Carbohydrates: Structure and classification of carbohydrates, monosaccharides, disaccharides and polysaccharides.

Chemistry of mono and di-saccharides: Pentoses, hexoses, deoxysugars, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides.

Chemistry of polysaccharides: Homopolysaccharides and heteropolysaccharides, starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate, chitin, xylans, bacterial cell wall polysaccharides, blood group polysaccharides.

Structure elucidation:degradation, graded acid hydrolysis, periodate oxidation, degradation of oxopolysaccharides, methylation, acetylation.

Glycobiology: Glycoproteins; Glycosidic bond, N- and O-glycosylation, lectins, carbohydrates in tissue engineering. Proteoglycans; agreecan, syndecan, and decorin. Pectin and pectic polysaccharides.

Unit-2

Amino acids: Nomenclature and classification.Zwitterionic structure and buffering properties. Reaction of amino acids. Unusual and non-protein amino acids.

Peptide bond: Features of the peptide bond. Naturally occurring peptides; glutathione, enkaphalins and endorphins. Chemical synthesis of peptides; solution phase synthesis, Merrifield's solid phase synthesis, and peptide ligation.

Primary structure of proteins: Determination of amino acid compositions and primary structure: Acid and base catalyzed hydrolysis, separation, quantification, determination of N and C terminal residues, determination of site of glycosylation and type of linkage

(o-glycosyl and n-glycosyl). Determination of s-s-bond position. Sequencing strategies; sequencing methods. Automated sequanators.

Unit-3.

Secondary structure of proteins: Helix**,** β-sheet, β-bend, β-turn and super secondary structures. Secondary structure prediction method; Ramachandran plot.

Tertiary and quaternary structures of proteins: Forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges. 3D Structure of myoglobin,hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin.

Protein folding: Denaturation and renaturation of proteins; Anfinsen's experiment. Molten globule, Levinthal paradox. Role of Chaperons in protein folding.

Introduction to protein modification: Glycosidic, phosphate, acetylation, methylation, hydroxylation and prenylation.

Isolation of proteins: overview of purification and criteria to establish protein purity.

Unit- 4

Lipids: Classification of lipids; oils, fats, and waxes. Occurrence and properties of fatty acids, esters of fatty acids, cholesterol, phospholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

Nucleic Acids: Structure of nucleosides and nucleotides. Isolation of DNA and RNA from biological sources.

Structure of DNA: Watson and Crick model; Chargaff's rule, B and Z DNA, other models of DNA structure. Secondary structural features in DNA.

DNA protein interaction:zinc finger, leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks.

Physiochemical properties of DNA:melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA.

Structure of RNA: Types, structure and physicochemical properties of RNA.Chemical reactions of RNA. Secondary structure of tRNA; cloverleaf model.Stem loop structure, palindromic sequences, cruciforms.

Sequencing of DNA: Maxam Gilbert method, dideoxy method.

Bioorganic and Bioinorganic Chemistry - 3 Credits 48 h

Objectives are:

- To study chemistry of biomolecules.
- To study organic reactions

Course outcome, the student will:

- Understand the bonds involved in the biomolecules and organic reactions

- Understand the stereochemistry of biomolecules and heterocyclic compounds.
- Understand the role of electrolytes in biological systems

Unit-1:

Bonding: Covalent bond; coordinate bond; coordinate bond formation in transition metals. Bonding of iron in hemologibin and cytochromes, cobalt in Vit B_{12}, magnesium in chlorophyll. Special properties of water; Structure and bonding. Crystal field theory; Ligand field theory and Valence bond theory. Chelators; types of ligands and complexes.

Unit-2:

Stereochemistry: Importance of stereochemistry, position and order of groups around carbon. Geometric and optical isomerism; absolute and relative configuration. Symmetry view of chirality, relation between chirality and optical activity, representation of chiral structures by Fischer. Structure and stereochemistry of sugars and amino acids; anomer, epimer, diastereomer, sterioisomer,
D and L, (+) and (-), R and S.

Unit-3:

Mechanism of organic reactions: Intermediates and rearrangements in organic reaction. Reaction energetic. Classification of rearrangement reactions. Reaction rates, order and molecularity of reaction. Mechanisms and stereochemistry of substitution (electrophilic and nucleophilic - sN^1 and sN^2 reactions) addition, elimination and rearrangement reactions. Mechanisms of ester hydrolysis. Property of aromaticity and resonance.

Unit-4:

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

Heterocyclic Compounds: Chemistry of furan, indole, thiazole, pterine, pteridine, isoalloxazine, pyrrole. Chemistry of porphyrins and heme and their biological importance.

Biochemical Techniques -3 Credits 48 h

Objectives are:

- To study various techniques involving biochemical principles.
- Optimization of techniques
- Advanced techniques

Course outcome, the student will:

- Understand various animal models used in biology
- Understand cell fractionation techniques using different type of centrifugation methods
- Understand separation and characterization of biomolecules using different chromatographic methods, electrophoretic methods and blotting techniques.

Unit-1:

Preliminary techniques in Biochemistry: Animal and Plant models, choice of animals, types of studies, mutant organisms (auxotroph), animal and plant cell culture.

Microbial techniques: Isolation and culture of microorganisms – aerobic, anaerobic and facultative culture methods and preparation of culture media. Isolation of pure colony and its characterization. Staining - Gram stain, acid fast,

endospore, flagella.

Cell fractionation techniques: Cell lysis, homogenization, extraction, salting in, salting out, dialysis and ultra filtration.

Unit-2:

Chromatographic techniques: Principles and applications of paper, TLC, adsorption, ion exchange, gel filtration, affinity, GLC, chromatofocusing, HPLC and FPLC.

Unit-3:

Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium; **Ultra centrifugation:** Differential and density gradient centrifugation, centrifugal elutriation.

Electrophoretic techniques: Polyacrylamide gel electrophoresis, SDS-PAGE,

2D-electrophoresis, diagonal, agarose gel electrophoresis, isoelectric focusing, pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis.

Visualizing proteins, glycoproteins, lipoproteins, and nucleic acids. Zymogram and reverse zymogram.

Unit-4:

Blotting techniques: Dot blot, Southern, Northern, Western blot, DNA foot print assay, DNA finger print assay, gel retardation assay, nuclease protection assay. RFLP, RAPD, PCR, RT-PCR, q-PCR, Microarrays.

Practical - 1: Biochemical techniques - 6 Credits

12 h/week

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn the preparations of various solutions.
- To learn various estimations of biomolecules using different methods.
- To develop skills for seminar presentation.

Course outcome the student will:

- Understand the basics of solutions and their preparations with respect to percent solution, molar and normal solutions.
- Understand separation and analysis of various biomolecules using chromatographic, colorimetric and titration methods.
- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Preparation of buffers pH titration of amino acid, formal titration.

Colorimetry**;** applications of Beer-Lambert's law, determination of extinction coefficient,

Carbohydrates: Purification of polysaccharides (Starch and Glycogen)Estimation of sugar by DNS and anthrone methods.

Amino acids and proteins:Separation of amino acids by ascending, descending, circular paper chromatography.

Estimation of protein by Biuret and Lowry's methods

Lipids:Extraction of neutral lipids, phospholipids and estimation of phospholipids.Titrimetric estimations. Iodine number, saponification value, acid value, peroxide value. TLC of lipids.

Nucleic acids: Estimation of DNA by DPA method and RNA by Orcinol method.

Courses - Soft Cores

Biophysical Techniques -3 Credits 48 h

Objectives are:

- To study properties of biomolecules with the help of spectroscopic methods and their optimization.
- To characterize biomolecules for their size, shape and structure.
- To study isotopes and its application in understanding biological process.

Course outcome, the student will:

- Understand the principles involved in different spectroscopic methods to analyze biomolecules.
- Understand different spectral analysis involved in determining the size, shape and structure of different biomolecules.
- Understand different types of isotopes and its applications in biological reactions and pathways.

Unit-1:

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications.

Unit-2:

Physical methods of determining size, shape and structure of molecules:

Magnetic Resonance: NMR and ESR; principles and applications.

Vibration Spectra: IR and Raman; principles and applications.

Light Scattering: Determination of size and shape of macromolecules, Zimm's method.

Polarized Light: Plane and circularly polarized light, ORD and CD

and their applications.

Unit-3:

X-ray Crystallography: Protein crystals, Bragg's law, unit cell, isomorphous replacement, fiber pattern of DNA. Turbidometry, flame photometry, atomic absorption, spectrophotometry; instrumentation and applications.

Electrospray Ionization, fragmentation, m/e, time of flight, MALDI and ESI. LC-MS, LC-MS-MS.

Unit-4:

Isotopes: Heavy isotopes and radio isotopes, theory and construction of mass spectrometer.

Radioisotopes in Biology: ^{3}H, ^{14}C, ^{32}P, ^{131}I, ^{35}S, concept of half-life, decay constant, detection and quantitation - GM counter and solid and liquid scintillation counter. Specific activity, autoradiography and their applications. **Applications of radioactivity:** Labeling of proteins and nucleic acids, Dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity.

Membrane Biology - 3 Credits 48 h

Objectives are:

- To study biological membrane structure and function.
- To study physiological process of biological membranes

Course outcome, the student will:

- Understand properties of biological membrane, and different models of membranes explaining the biological function.
- Understand membrane asymmetry and other properties using various methods.
- Understand the complex mechanism involved in transportation of biomolecules across membranes.

Unit-1:

Physico-chemical properties of membranes: Compositionsand supra molecular organization. Membrane lipid phases; bilayer phase, non-bilayer phase, phase transition and membrane potential.

Models of membrane: Evolution in concept of membrane models, Gorter and Grendel's experiment. Bilayer structure; Danielle - Davson model of membrane, Singer and Nicholson's model and Newer models.

Membrane asymmetry; Membrane lipids, proteins and carbohydrates and their lateral diffusion. Biogenesis of lipids and proteins, polarized cells, membrane domains; caveolae, rafts and protein turnover. Intracellular targeting of proteins. Biogenesis of sub cellular organelles.

Unit-2:

Methods of study of membrane structure: Lipid transfer proteins, phospholipases, chemical methods, amino-phospholipid translocation, TNBS reagent, freeze fracture and freeze etching. Lipid vesicles; liposome preparations and application, function of sterols in membranes. FRET, FRAP, single particle tracking, EM of membranes, calorimetry, confocal microscopy of membrane dynamics. Cell fusion, shedding of membrane.

Unit-3:

Membrane transport: Laws of diffusion across membranes; simple diffusion, facilitated diffusion and active transport. Glucose transporters, Ca^{2+} ATPase, Na^{+}-K^{+}ATPase (Structure and mechanism of action). Endocytosis, receptor mediated endocytosis, exocytosis, ion channels; gated and non-gated, aquaporin channel.Bacterial phosphotransferase system.

Unit-4:

Nerve transmission: Structure and types of Neuron. Acetylcholine receptor and neurotransmitters, mechanisms of nerve conduction, resting and action potential, ion channels, ionophores, patch clamp technique. Presynaptic and postsynaptic membranes. Nicotinic and muscarinic neurons. GABA, NMDA, structure and function.

Muscle contraction: Mechanisms, role of calcium, calmodulin, and phospholamban.

Plant Biochemistry - 3 Credits 48 h

Objectives are:

- To study major biochemical reactions in plant system.
- To study secondary metabolites and its role in host parasite interaction.

Course outcome, the student will:

- Understand the harvesting solar energy to chemical energy by photosynthesis, solute transport and photo assimilate translocation process
- Understand nitrogen metabolism and various plant hormones in different stages of plant development.
- Understand various phytochemicals as secondary metabolites and their role in plant defense system.

Unit-1:

Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. Electron flow and photophosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C3, C4 and CAM cycle. Photorespiration. Bacterial photosynthesis. Regulation of photosynthesis. RUBISCO.

Nitrogen metabolism: Importance of nitrogen in biological systems. Nitrogen cycle; Nitrogen fixation, symbiotic and non-symbiotic, nitrogenase complex, energetics and regulation. Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion.

Unit-2:

Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and mechanisms of action of auxines, gibberlines, cytokinins, ethylene, abscisic acid and jasmonic acid.

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, photoperiodism and biological clocks. Seed dormancy, inception of germination. Germination and growth regulators, juvenility, vernalization.

Unit-3:

Solute transport and photo assimilate translocation: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil through xylem and phloem. Transpiration, mechanisms of loading and unloading of photoassimilates.

Phytochemicals: Secondary metabolites**;** Terpenes, phenols, flavonoids and nitrogenous compounds and their roles in plant physiology and as alternative medicine. Extraction, fractionation and characterization of phytochemicals.

Unit-4:

Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, fungi and viruses. Pathogen-induced diseases in plants. Alteration of host cell behaviour by pathogens, virus-induced cell transformation. Cell-cell fusion in both normal and abnormal cells. Plant defence system.

References

1. Clayden G, Warren W, Greeves N, Wothers P „Organic Chemistry “, 2001. Oxford University Press.
2. Morrison R, Boyd R (1992) Organic Chemistry, 6th. Englewood Cliffs, NJ: Prentice Hall.
3. Sykes P (1986) A guidebook to mechanism in organic chemistry: Pearson Education India.
4. Mathews P (2002) Advanced chemistry, cambridge low price editions. Cambridge University Press UK.
5. Bahl A (2010) Advanced organic chemistry: S Chand & Company Limited.
6. Eğe SN (1989) Organic chemistry: DC Heath.
7. Wilson K, Walker JM (2000) Principles and techniques of practical biochemistry: Cambridge University Press.
8. Nelson DL, Lehninger AL, Cox MM (2008) Lehninger principles of biochemistry: Macmillan.
9. Bergethon PR (1998) The physical basis of biochemistry: the foundations of molecular biophysics: Springer Science & Business Media.
10. Creighton TE, Chasman DI (1997) Protein structure: a practical approach: IRL press Oxford.
11. Adams RLP, Knowler JT, Leader DP (1992) The biochemistry of the nucleic acids: Chapman and Hall.
12. Berg JM, Tymoczko JL, Stryer L (2006) Biochemistry: international edition: WH Freeman & Company Limited.

13. Voet D, Voet JG (1995) Biochemistry. New York: J. Wiley & Sons.
14. Zuby G (1988) Biochemistry, 236New York. MacMillan.
15. Wilson K, Walker J (2010) Principles and techniques of biochemistry and molecular biology: Cambridge University Press.
16. Pigman W (2012) The carbohydrates: chemistry and biochemistry: Elsevier.
17. Marshall AG (1978) Biophysical chemistry: principles, techniques, and applications: Wiley New York.
18. Dey PM, Harborne JB (1997) Plant biochemistry: Academic Press.
19. Goodwin TW, Mercer EI (1983) Introduction to plant biochemistry.
20. Buchanan BB, Gruissem W, Jones RL (2000) Biochemistry & molecular biology of plants: American Society of Plant Physiologists Rockville.
21. Singhal G (1999) Concepts in photobiology: photosynthesis and photomorphogenesis: Springer Science & Business Media.
22. Moore TC (1979) Biochemistry and physiology of plant hormones: Springer-Verlag.
23. Branden CI (1999) Introduction to protein structure: Garland Science.
24. Creighton TE (1993) Proteins: structures and molecular properties: Macmillan.

II Semester Biochemistry

Courses - Hard Cores

Enzymology - 3 Credits 48 h

Objectives are:

- To study general aspects of enzymes and its classification.
- To study the mechanisms of enzyme reactions using inhibitors and activators

Course outcome, the student will:

- Understand enzymes, their activity measurements and kinetic reactions.
- Understand enzyme reactions using inhibitors and activators to understand nature of catalysis, mechanism of action and type of inhibition.
- Understand the regulation of enzymes in metabolic reactions.

Unit-1:

General aspects: Nature of enzymes, localization, isolation, purification and characterization of enzymes. Marker enzymes, criteria of purity of enzymes, fold purity. Nomenclature and IUB classification of enzymes. Enzyme specificity, specific activity, assay methods; coupled enzyme assays, continuous, end point and kinetic assay. Units of enzyme activity, IU and Katal. Activation energy, free energy change, binding energy.

Unit-2:

Enzyme kinetics: Michaelis-Menten equation for uni substrate reactions, initial velocity approach, steady state approach. Vmax, Km and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden. Scatchard plot.

Rate of a reaction, order and molecularity. I order reaction kinetics. Rectangular hyperbola, Michaelis-Menten equation as rectangular hyperbola, linear transformation, calculation and significance of slope, intercept.

Inhibition: Reversible and irreversible inhibition; competitive, non competitive, uncompetitive product inhibition and suicide inhibition. Feed back inhibition, feed forward inhibition. Determination of Ki and Kd.

Unit-3:

Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions.

Cooperativity: Binding of ligands to macromolecules; Scatchard plot, positive and negative cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyltranscarbamylase as an allosteric enzyme.

Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure. Isolation of ES complex, affinity labeling, chemical modification studies, site directed mutagenesis.

Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucleophilic and electrophilic catalysis, intramolecular catalysis, entropy effects. Effect of temperature and pH on enzyme catalysed reaction.

Unit-4:

Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay net work. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes,

coenzymic action of NAD^+, FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid.

Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC).

Metabolic regulation of enzyme activity: Feedback regulation, fine control of enzyme activity. Fast reactions - Stopped flow, temperature jump method with examples of enzymes.

Metabolism of fuel molecules - 3 Credits 48 h

Objectives are:

- To study different aspects of catabolism, anabolism and amphibolic pathways of carbohydrate and lipid metabolism
- To study synthesis of high energy compounds, energy utilization and disorders of carbohydrate metabolism.
- To study lipid synthesis and its degradation.
- To study Lipid metabolism, intermediate metabolism and its regulation.

Course outcome, the student will:

- Understand the degradation of carbohydrates via glycolysis, citric acid cycle and its regulations including hormonal during the synthesis of high energy compounds and their utilization.
- Understand biosynthesis of sucrose, lactose, starch and glycogen.
- Understand biosynthesis and degradation of lipids in relation to energy production and energy conservation.
- Understand the role of cholesterol and other lipids in normal and diseased conditions.
- Understand the general lipid metabolism and intermediate metabolism in energy storage mechanism.

Unit-1:

Introduction - Catabolism, anabolism, and amphibolic pathways.

Carbohydrates: Cellular ingestion of glucose, glycolysis, energetics regulation. Pathways of utilization of pyruvate-lactate, ethanol, gluconeogenesis, regulation, Cori cycle, glucose paradox, citric acid cycle its regulation, energetics, anaplerosis, glyoxylate cycle. HMP shunt pathway, inter conversion of hexoses. Utilization of non glucose sugars. Biosynthesis of sucrose, lactose, starch and glycogen.

Hormonal regulation of glycogen metabolism: Effect of hormones on carbohydrate metabolism; insulin, glucagon, catecholamines, growth hormones, corticosteroids and thyroid hormones in different tissues. Secretion of Insulin and glucagon in response to various stimuli (Fasting, food, intestinal hormones). Disorders of carbohydrate metabolism: diabetes mellitus.

Unit-2:

Energy Utilization: I, II and III laws of thermodynamics. enthalpy, entropy, free energy. High energy compounds, **e**nergy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound.

ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. Substrate level phosphorylation, futile cycles and their application.

Mitochondrial electron transport: Entry of reducing equivalents for oxidation; malate-aspartate shuttle, glycerol phosphate shuttle. Organization of respiratory chain complexes, structure and function of the components; Fe-S proteins, cytochromes, Q cycle, proton transfer, P/O ratio, respiratory control, oxidative phosphorylation, uncouplers and inhibitors, sequence of electron carriers based on red-ox potentials.

Unit-3:

Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; lipase, hormone sensitive lipase, phospholipases and sphingomyelinase. Fatty acid degradation; β-oxidation Knoop's experiment, saturated and unsaturated fatty acids. α and ω oxidation Regulatory aspects.

Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachiodnante.

Lipid mediators: An introduction to Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG, ceramide and PAF.

Unit-4:

Cholesterol synthesis, degradation, and regulations, cholesterol lowering drugs: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL. Oxidized lipids, foam cell formation.

Phospholipid biosynthesis and regulations: Denovo pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Degradation and biosynthesis of gangliosides and cerebrosides.

Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation.

Practical - 2:

Experiments in Enzymology and Metabolism- 6 Credits

12 h/week

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn colorimetric estimation of biomolecules.
- To learn enzyme assays.

Course outcome, the student will:

- Understand the estimation of proteins by different colorimentric methods
- Understand different enzyme assays with respect to specific activity, Km, Vmax and effect of pH, temperature and substrates.

Protein assays: FC method, Biuret method, Lowry's method and Coomassie blue dye binding.

Enzymes: Salivary Amylase, Protease and Invertase from latex, Esterase from Pea and alkaline phosphatase from milk.

Specific activity, pH and temperature optimum, energy of activation, Km and Vmax. Ammonium sulphate fractionation of esterase from Pea. GOD-POD. Photo-oxidation of methylene blue.

Courses: Soft cores

Physiology - 3 Credits 48 h

Objectives are:

- To study different systems operating in living organisms.

Course outcome, the student will:

- Understand various systems and their physiological functions.
- Understand blood and its composition, nervous, respiratory, excretory, digestive and muscle physiology.

Unit-1:

Blood: Composition, cells, plasma proteins and lipoproteins, preparation of plasma, serum, and different blood cells. Erythrocytes; shape and function. WBC; types, differential count and functions. Platelets and their function. Half-life of blood cells. Buffer systems, hemostasis, blood clotting, different pathways of blood clotting, mechanisms of initiation of clotting pathways, various enzyme complexes digestion of

clot, anticoagulants, blood volume, blood pressure and its regulations. Plasma lipoproteins and their functions, HDL, LDL, VLDL, chylomicrons.

Unit-2

Respiratory System: Lungs, structure and functions, gas exchange, oxygen binding by hemoglobin, factors affecting oxygenation and acid-base balance.

Nervous system: Structure of a neuron, nerve transmission, mechanism of neurotransmission, action potential, synapse, different types of neurotransmitters, stimulatory and inhibitory, central and peripheral nervous system, neuro-muscular junction. Parts of brain, brain-gut interaction, ion channels, types of ion-channels, secretion of neurotransmitters, CSF; composition and function.

Unit-3

Excretory System: Ultra structure of the nephron, glomerular filtration, filtration rate, mechanism of formation of urine, acid-base balance. Consequences of imbalance in acid-base balance, formation of kidney stones. Kidney function tests

Hepatobiliary System: Anatomy of the liver, blood supply, cells; hepatocytes, endothelial cells and Kupffer cells, secretory and excretory functions and formation of bile. Role of liver in detoxification.

Unit-4

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Mechanism of HCI production in the stomach. Gastrointestinal hormones and role of pancreas in digestion.

Muscle physiology: Types of muscle, structure of skeletal muscle and smooth muscle, muscle proteins; actin, myosin, tropomyosine, troponins. Mechanisms of skeletal and smooth muscle contraction, sliding filament model.

Nutritional Biochemistry-3 Credits 48 h

Objectives are:

- To study the nutritional aspects for the functioning of the body.

Course outcome, the student will:

- Understand the various factors affecting the basal metabolism and their physiological functions.
- Understand the nutritional values of vitamins, minerals, proteins, carbohydrates, and lipids.
- Understand the beneficial effects of food components in the management of disorders.

Unit-1

Nutrition: Concepts of macro and micro nutrients, essential nutrients and their classification. Food groups, proximate analysis of foods, chemical and biological analysis for nutrients. Food as source of energy, methods of determining energy value of foods, calorimetry, physiological fuel value, daily requirement of energy, high and low calorie diets. Basal metabolic rate (BMR), factors affecting BMR, specific dynamic action of foods.

Unit-2

Carbohydrates: Dietary sources, dietary fiber, essentiality of carbohydrates. Carbohydrate storage. Proteins: Essential amino acids, evaluation of nutritive value of dietary proteins, PER, BV, nutritional classification of proteins, supplementary value of proteins, protein calorie malnutrition; Kwashiorkar and Marasmus. Fats: Dietary value of fats and lipids, Sources, invisible fat, essential fatty acids, PUFA. w-3, w-6 fatty acids, DHA, EPA.

Unit-3

Vitamins: Fat soluble and water soluble vitamins, provitamines, antivitamins, dietary sources, daily requirements, structure and function. Deficiency symptoms of water soluble and fat soluble vitamins, hypervitaminosis, vitamin - like compounds.

Minerals: Macro and micro nutrients, sources, requirements, functions and deficiency symptoms. Water metabolism; distribution in body, water balances and factors affecting water balance.

Unit-4

Diet: Recommended daily allowances, special nutrition for infants, children, during pregnancy, lactation and old age. Therapeutic nutrition for diabetes and cardiovascular disease patients. Wellness diets, fitness diets, obesity and BMI, mediterranian diet, nutrients as antioxidants, diet and cancer, food preservatives, food adulterants'.

Biostatistics - 2 Credits 32 h

Objectives are:

- To study the sampling techniques and significance of biostatistics.
- To study the collection and representation of statistical data.
- To study the applications of various means of statistical analysis.

Course outcome, the student will:

- Understand the collection and graphical representation of statistical analysis.
- Understand the sample size and hypothesis testing.
- Understand the various means of statistical analysis including t test, ANOVA, correlation and regression.

Unit-1:

Introduction to Biostatistics: Population, sample, sampling techniques, random sample. Mean, median, mode, range, variance, coefficient of variation, frequency, standard deviation, standard error.

Unit-2:

Collection of data: Relevance of sample size. Sources, methods-questionairs, records, archives, scaling-Likert and Gutman. Validation and standardization of the methods, modification and experimental design. Representation of statistical data line graph, histogram, bar diagram, pie chart, scatter diagram.

Unit-3:

Probability: Rules of probability, binomial distribution, normal distribution, area under the curve, Z value, choosing sample size, hypothesis testing, Student's t test. One way ANOVA, correlation and regression.

Unit-4:

X2 test: goodness of fit, test of independence.

Non parametric statistics, sign test, rank sum test, rank correlation.

References.

1. Nelson DL, Lehninger AL, Cox MM (2008) Lehninger principles of biochemistry: Macmillan.
2. Devlin TM (2011) Textbook of biochemistry: with clinical correlations.
3. Voet D, Voet JG (1995) Biochemistry. New York: J. Wiley & Sons.
4. Zuby G (1988) Biochemistry, 236New York. MacMillan.
5. Smith EL (1983) Principles of biochemistry: mammalian biochemistry: McGraw-Hill Companies.
6. Chatterjee CC (1951) Human physiology: Medical Allied Agency.
7. Murray R, Granner D, Mayes P, Rodwell V (2003) Harper's illustrated biochemistry (LANGE basic science): McGraw-Hill Medical.
8. Guyton Aurcher C, Hall John E (2006) Text book of Medical Physiology. Elsevier India Pvt. Ltd. New Delhi.
9. Dixon M, Webb E (1979) Enzyme inhibition and activation. Enzymes 3: 126-136.
10. Rao C (1973) University General Chemistry: An Introduction to Chemical Science: MacMillan India.
11. Fersht A (1985) Enzyme structure and mechanism.
12. Price NC, Frey PA (2001) Fundamentals of enzymology. Biochemistry and Molecular Biology Education 29: 34-35.
13. Palmer T, Bonner PL (2007) Enzymes: biochemistry, biotechnology, clinical chemistry: Elsevier.

III Semester Biochemistry

Courses - Hard Cores

Molecular biology - 3 Credits 48 h

Objectives are:

- To study basics of molecular biology.
- To study the molecular mechanism involved in the storage of information and transfer of information from one generation to next generation.

Course outcome, the student will:

- Understand the historical discovery made and the methodology employed to establish that DNA is the genetic material.
- Understand the molecular process of transcription, translation process while transferring genetic information from DNA to protein via RNA molecules.
- Understand the enzymatic steps involved in each process and their regulations.

Unit – 1:

Introduction: Historical perspective, composition of RNA and DNA. Bases, Chargaff's rule. Types of RNA. Isolation and purification of RNA and DNA, structure of RNA and DNA, central dogma of molecular biology.

DNA-antiparellel nature: Nearest neighbour base frequency analysis. Replication of DNA – modes (unidirectional, bi-directional), semi conservative nature; Messelson and Stahl experiment. Replication of double stranded DNA, direction of replication, discontinuous replication, Okazaki fragments.

Unit - 2:

Prokaryotic and Eukaryotic DNA polymerase I II and III (proof reading activity), DNA ligase, DNA topoisomerases, DNA primase, DNA helicase. DNA damage and repair mechanism. Fidelity of replication. Replication in viruses, rolling circle model, single stranded DNA virus. Applications of mitochondrial DNA. Trombon model, translesion synthesis (DNA pol IV and V).

Transcription: Co-linearity of genes and proteins, RNA polymerase I, II and III. Activators, enhancers, repressors of transcription, transcription factors, RNA biosynthesis in prokaryotes and eukaryotes; initiation – regulatory elements, formation of pre-initiation complex, elongation and termination., RNA dependent RNA synthesis, RNA replicase of Qβ virus. Processing of eukaryotic RNA, cap addition, poly A tail addition, RNA editing. Processing of tRNA and mRNA transcripts.

Unit – 3:

Translation: Genetic code, triplet codon, universality features of the genetic code, assignment of codons, studies of Khorana, Nirenberg, triplet binding techniques, degeneracy, wobble hypothesis, evolution of genetic code and codon usage, variation in the codon usage.

3D structure of prokaryotic and eukaryotic ribosomes, ribosomal protein synthesis; initiation – charging of tRNA, formation of initiation complex (40S & 80S), recognition of initiation codon, regulation of initiation, elongation (binding of aminoacyl t-RNA to A site; Peptide bond formation; Translocation) and termination; recycling of ribosomes. Role of mRNA and tRNA. Aminoacyl tRNA and its role in translation accuracy.

Unit – 4:

Post translation modification of proteins, signal cleavage, disulphide bond formation, O and N-glycosylation, folding of nascent protein, types and role of chaperones, attachment of glycosyl anchor, and other modifications. Protein misfolding and associated disorders

Enzymes in DNA and RNA degradation: Nucleases, ribonucleases, classification and role.

Metabolism of Nitrogenous compounds - 3 Credits 48 h

Objectives are:

- To study metabolism of Proteins
- To study the nitrogen metabolism and photosynthesis.
- To study the metabolism of nucleic acids.

Course outcome, the student will:

- Understand the biosynthesis and degradation of amino acids
- Understand the detailed synthesis and degradation of purines and pyramidines pathways and its disorders.

Unit – 1:

Proteins: General mechanisms of degradation in cells; ubiquitin-proteosome pathway, lysosomal pathway.

Degradation and biosynthesis of glycoproteins and proteoglycans.

Degradation and biosynthesis of heme.

Non ribosomal peptide synthesis: glutathione, gramicidine.

Unit – 2:

Biosynthesis of physiologically active amines; serotonin, histamine, dopamine, norepinephrine and epinephrine.

General mechanisms of amino acid metabolism and regulations: Role of cofactors; PLP, FMN and THF in amino acid metabolism. Deamination, transamination, decarboxylation desulphuration process. Urea cycle.

Unit – 3:

Metabolic breakdown of individual amino acids. Biosynthesis of non-essential amino acids in human and synthesis of essential amino acids in microbes and plants.

Regulation of amino acid biosynthesis; transglutaminase cycle.

In born errors of amino acid metabolism - Phenylketonuria, Alkaptonuria, Maple syrup urine.

Unit – 4:

Purines and pyrimidines: Pathways of biosynthesis and degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations.

Conversion of nucleotides to deoxynuclotides. Gout and Lysch-Nyhan syndrome Mechanisms of action of methotrexate, 5-fluorouridine, azathymidine.

Biosynthesis of cofactors: NAD^+, FAD and coenzyme A, polyamine biosynthesis and their metabolic role.

Immunology - 3 Credits 48 h

Objectives are:

- To study basics of defense system.
- To study cellular basis and humoral basis of immunity
- To study Immune systems during transplantation

Course outcome, the student will:

- Understand the basics involved in cell mediated and humoral mediated defense mechanism.
- Understand primary and secondary immune response in cell mediated responses and production of cytokines and co-stimulatory molecules in humoral mediated responses.
- Understand the biochemical process involved during transplantation and during tumor formation.

Unit-1:

Introduction: Historical development and milestones in immunology. Definitions; antigenicity, immunogenicity, innate and acquired immunity. Cells and agents of innate immunity. Primary and secondary lymphoid organs, self and non self discrimination. Antigens and antibodies; haptens and determinants epitopes and paratopes. Antigenicity, carbohydrates, proteins, nucleic acids, and cells as antigens. Valency of antigen, epitope analysis.

Classes and subclasses of immunogloblins, structure of immunoglobulins, hyper variable region isotypic, allotypic and idiotypic variation.

Unit-2:

Cellular Basis of Immunity: Primary and secondary immune response. Reticuloendothelial system, B and T and accessory cells. Development of B and T cells. Sub sets of B and T cells. T-helper cells, T-killer cells, T-suppressor cells. B and T cell receptors, antigen processing and presentation. B and T interaction. Cytokines and co-stimulatory molecules; lymphokines, interleukins, structure and function of IL-lβ, IL-2, TNFα. Suppression of immune response, immunoglobulin genes, generation of immunoglobulin diversity, gene rearrangement and other mechanisms, clonal selection theory of Burnet.

Unit-3:

MHC: MHC gene and its polymorphism, role of MHC in immune response and transplantation.

Transplantation: Autograft, isograft, allograft and xenograft. Graft rejection, graft vs. host reaction. Immunosuppressive drugs.

Tumour immunology: Tumour associated antigens, factors favoring tumour growth, immune surveillance. Tumour necrosis factor α and β. Antitumour drugs.

Unit-4:

Disorders of immunity: Immunological tolerance, auto immune disorders, AIDS, SCID. Systemic Lupus Erythomatosus.

Vaccines: Adjuvants, vaccines and their preparations. Polyclonal and monoclonal antibodies; hybridoma technique.

In vitro antigen-antibody reaction: Precipitation, agglutination, complement fixation, immuno diffusion, immunoelectrophoresis, immunofluorescence, RIA, ELISA.

Practical-3:

Experiments in Immunology & Clinical Biochemistry-

6 Credits 12 h/week

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn colorimetric estimation of metabolites.
- To learn assays if clinically significant enzymes.
- To develop skills for seminar presentation.

Course outcome, the student will:

- Understand the clinical significance of measuring various metabolites such as glucose, pyruvate, ascorbic acid, iron, calcium and phosphorus.
- Understand different functional analysis such as lipid profile, diabetes profile, liver and kidney profile.

- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Estimation of pyruvate, ascorbic acid, iron, calcium, phosphorus,

Lipid profile Total cholesterol, Triglycerides in serum.

Diabetic profile: Fasting blood sugar, Post-prandial blood sugar, GTT by GOD and POD method.

Renal function test: Urea and creatinine.

Liver function test: Bilirubin, SGOT, SGPT, Alkaline Phosphatase, LDH, Albumin and globulin ratio.

Blood grouping. Ouchterlony diffusion test; Purification of antibody from egg.

Courses: Soft cores

Clinical biochemistry - 3 Credits 48 h

Objectives are:

- To study the basics of health and diseases.
- To study disease associated with blood, liver, kidney, gastrointestinal system and endocrine system.
- To study metabolic disorders

Course outcome, the student will:

- Understand the concept of health and diseases with respect to infectious and non-communicable disease
- Understand the various investigations to study the disorders of blood, liver, kidney, gastrointestinal system and endocrine system.
- Understand metabolic disorders with respect to diabetes and coronary heart diseases.
- Understand the hypo and hyperactivities of all the endocrine organs and their manifestation in various disorders.

Unit-1:

Basic concepts: Health and disease. Normal and pathological changes, affecting cells in the body. Cell death and the physiological causes; physical, chemical, biological agents and nutritional deficiency.

Blood: Composition, cells, functions of plasma proteins and lipo-proteins in diseases. Disorders of hemoglobin; thalassemia, sickle cell anemia.

Anemias; microcytic, normocytic and macrocytic.

Diagnostic enzymology: Clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatine kinase and LDH.

Unit-2:

Endocrine disorders: Laboratory diagnosis to assess the function of pituitary, thyroid, adrenals and gonads.

Disroders; Graves' disease, Hashimoto disease, Addission's disease, hypo and hyper secretion of hormones. Acromegaly, gigantism.

Liver: Biochemical indices of hepatobiliary diseases. Diagnosis of liver function tests. Bile pigments - formation of bilirubin, urobilinogen, bile acids.

Jaundice; prephapatic, hepatic and post hepatic.

Diseases of the liver - Hepatitis cholestasis, cirshosis, fatty liver and gallstones.

Kidney: Assessment of renal function; creatine clearance, renal calculi, uremia, laboratory investigation of kidney disorders.

Unit-3:

Gastrointestinal disorders: Fractional gastric analysis, hypo and hyper acidity, gastric ulcers, malabsorption syndrome, steatorrhea and diarrhoea.

Metabolic disorders: Amino acid, lipid, nucleic acid and carbohydrates: Phenylketone urea, alkapton urea. Lesch-Nyhan, Gout. Diagnosis of metabolic disorders, Amniocentesis.

Disorders of carbohydrate metabolism; diabetes mellitus, classification, etiology, management. Laboratory investigations; GTT, HbAlc, diabetic complications and advanced glycation end products.

In born errors of carbohydrate metabolism; glycogen storage diseases, galactosemia, lactose intolerance, pentosuria.

Unit-4:

Cardiovascular disorders: Major Cardio vascular system, atherosclerosis, risk factors and pathogenesis. Diagnosis and prognosis.

Determination of lipids and lipoproteins. Hyper lipoprotenemia and types of modification of lipoproteins. Taysachs, Nieman- Pick disease, Fabry's disease.

Cancer: Etiology, diagnosis, treatment and prognosis. Carcinogens, oncogens, mechanism. Biochemistry of ageing: Cellular senescence, cystic fibrosis. Mechanism of detoxification of xenobiotics.

Genomics and Proteomics - 2 Credits 32 h

Objectives are:

- To study the basics genomics, proteomics through bioinformations.
- To study various data bases and servers involved.
- To study molecular modeling and drug designing.

Course outcome, the student will:

- Understand the biological databases and related software employed to analyze DNA sequences, protein sequences,
- Understand the generation and prediction of different molecular structural modeling from the available data.
- Understand molecular phylogenetics based on the existing sequence data
- Understand proteomics and sequence analysis using various softwares.
- Understand designing a drug and its interaction with the ligands.

Unit-1:

Introduction to Genomics: DNA isolation, sequencing by dideoxy method and next generation sequence analysis. Hybridization methods, microarray analysis, and reverse transcribed and real time PCR.

Biological databases: Introduction, classification of biological databases, retrieval of biological database systems. Molecular Modeling Database at NCBI, Molecular visualization software (RASMOL). Phylogenetics Clustal. Prediction of genes (Gene finder, ORF finder).

Unit-2:

Sequence comparison and database search: Introduction, pair wise alignment, global alignment, local alignment, multiple sequence alignment, scoring a multiple alignment, multiple sequence alignment, methods-dynamic programming approach, progressive

alignment, iterative refinement methods, pattern matching in DNA and protein sequences, PAM matrices, BLAST, FAST and FASTA. Nucleotide sequence analysis, tools and methods, single nucleotide polymorphism.

Molecular phylogenetics: Introduction, application of phylogenetic trees, basic terminology, taxa, taxanomy, root, leaf, node, tree, branch, clade, dendogram, cladogram, rooted tree, unrooted tree, scaled tree. Phylip, Clustal.

Unit-3:

Introduction to proteomics: Analytical methods of protein and peptide separations, protein digestion techniques, Mass spectrometers for protein and peptide analysis. Protein identification by peptide mass fingerprints, peptide sequence analysis by tandem mass spectrometry.

Protein sequence analysis using softwares; Emboss, data mining proteomes, motif mapping using prosite, prodom, protein expression profiling, protein-protein interactions, protein complexes. Mapping protein modifications. Protein secondary structure analysis, Molecular visualization, protein 3D structure using Rasmol, pdb file format.

Unit – 4:

Protein and secondary structure prediction: Secondary structure prediction methods, softwares for secondary structure prediction, protein families and classification, prediction of transmembrane regions. CATH and SCOP.

Protein modeling: Introduction, methods of protein modeling, homology or comparative modeling, model refinement, evaluation of the model.

Courses - Open Electives

Fundamentals of Biochemistry - 4 Credits 48 h

Objectives are:

- To study basics of vital physiology.
- To study the key biomolecules involved in exerting physiological functions.

Course outcome, the student will:

- Understand the significance of blood and its components for physiological functions.
- Understand the physiology of nervous system, digestive system, muscle physiology.
- Understand the nutritional aspects of sugars, proteins, amino acids, lipids, nucleic acids, minerals and vitamins.
- Understand the toxicity of xenobiotics used as medications to cure diseases.

Unit-1:

Blood: Composition, cell types red blood cells and white blood cells and their function. Hemostasis, blood clotting, digestion of clot, anticoagulants, blood volume, blood pressure and serum enzymes.

Respiratory System: Lungs, structure and functions, exchange of gases,

Unit-2:

Excretory System: Ultra structure of the nephron, formation of urine.

Hepatobiliary System: Anatomy of the liver, cells types.. Secretory and excretory function and formation of bile.

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Function of HCl

Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins;

Unit-3:

Nutrition: Small molecules: sugars, amino acids, nucleotides, lipids. Macromolecules: polysaccharides, proteins, nucleic acids.

Carbohydrates: Dietary sources, dietary fiber, essentiality of carbohydrates.

Proteins: Essential amino acids, nutritional classification of proteins, supplementary value of proteins, protein malnutrition.

Fats: Sources, invisible fat, essential fatty acids, PUFA.

Vitamins: Classification, source, deficiency symptoms Fat soluble and water soluble vitamins.

Unit-4:

Minerals and Water metabolism: Macro and micro nutrients, sources, requirements, functions and deficiency symptoms. Water metabolism; distribution in body, water balances, factors affecting water balance.

Implications in health and disease: Diabetes Hyper tension, Hypotension

Gouti arthritis,

Immunology: Historical development and milestones in immunology Vaccines and Vaccination.

Toxicity: Xenobiotics, heavy metals, pesticide poisoning.

Tutorials: Discussion, demonstration, laboratory visits.

References:

0. Alberts B, Bray D, Lewis J, Raff M, Roberts K, et al. (1995) Molecular Biology of the Cell (3rd edn). Trends in Biochemical Sciences 20: 210-210.
1. Watson JD (1970) Molecular biology of the gene. Molecular biology of the gene.
2. Karp G, Iwasa J, Marshall W. (2019). Karp's Cell and Molecular Biology (9 Edn). New York: Wiley & Sons
3. Lodish HF, Berk A, Zipursky SL, Matsudaira P, Baltimore D, et al. (2000) Molecular cell biology: WH Freeman New York.
4. Griffiths AJ (2005) An introduction to genetic analysis: Macmillan.
5. Kornberg A, Baker TA (1980) DNA replication: WH Freeman San Francisco.
6. Lewin B (1999) Genes VII. Oxford University Press New York.
7. Nelson DL, Lehninger AL, Cox MM (2008) Lehninger principles of biochemistry: Macmillan.
8. Voet D, Voet JG (1995) Biochemistry. New York: J. Wiley & Sons.

IV Semester Biochemistry

Courses - Hard Cores

Cell Biology - 3 Credits 48 h

Objectives are:

- To study the basic components of a cell and its regulation.
- To study endocrine systems and their regulations.
- To study the mechanism of actions of hormones

Course outcome, the student will:

- Understand the detailed structure of a cell and the involvement of various organelles in the synthesis of protein, amino acid and steroid hormones.
- Understand the various endocrine organs in relation to the regulation of various metabolic processes.
- Understand the hypo and hyperactivities of all the endocrine organs and their manifestation in various disorders.

Unit-1:

Cell: Structure of a cell, mitosis**,** meiosis**,** cell cycle and its regulation, different phases of cell cycle. Apoptosis, cyclins and CDKs. Cell-cell and cell-ECM interaction and ECM structure and function.

Endocrine System: Endocrine organs in man. Location and inter relationship of endocrine glands in man; classification and chemistry of hormones, hormones of hypothalamus, pituitary, thyroid, parathyroid, pancreas, liver, adrenals, gonads and intestine.

Unit-2:

Functions and abnormalities: Hypo and hyper production of hormones secreted by; pituitary, thyroid, pancreas, adrenals and gonads.

Structure and control of hypothalamus function: Hormones produced; GRH, somatostatin, TRH, CRH, GnRH.

Pituitary gland: Structure, hormones of anterior, posterior and median lobes. Pro-opiomelanocortin.

Testes and ovaries: Structure, hormones produced by testes and ovaries, menstrual cycle.

Regulation of hormone production and release: hypothalamus-pituitary-target organ axis and regulation by feedback mechanism.

Unit-3:

Mechanism of hormone action: Peptide hormones: General mechanisms of cell signaling by hydrophilic factors, transmembrane receptors, transmembrane receptors, G protein coupled receptors, receptor tyrosine kinase, eicosanoid receptors.

Second messengers: $1P_3$, DAG, cAMP, protein kinases. Nitric oxide signaling; generation and action.

Growth factors: Structure, mechanism of action and receptors of EGF, PDGF, NGF and IGF. insulin receptor.

Unit-4:

Mechanism of action of steroid hormones: Conversion of cholesterol to steroid hormone.Steroid receptors, isolation and characterization of steroid receptors. Receptor down regulation, desensitization and up regulation.

Pineal gland, melotonin and circadian rhythm.

Chemistry and action of prostaglandins, prostacyclins and thromoxanes.

Newly discovered hormones

Insect hormones: Structure and function of moulting hormone, ecdysone, juvenile hormones, Pheromones. Application of insect hormones.

Gene Regulation - 3 Credits 48 h

Objectives are:

- To study basics genetics and regulations of genetic materials.
- To study chromosomal aberrations, repair mechanisms and genetic disorders.

Course outcome, the student will:

- Understand the early genetic work from Mendelian laws up to recent molecular study of genetic principles.

- Understand the various aberration processes and the repair mechanism.
- Understand the regulations of gene in both prokaryotes and eukaryotes.
- Understand the genetic disorders.

Unit-1:

Organisation of genes in prokaryotic and eukaryotic Chromosome: Structure of bacterial chromosome, structure of eukaryotic chromosome, nucleosome organization, arrangement of chromatin fibers in a chromsome. Genome size and evolutionary compplexcity, C-value paradox.

Unit-2:

Regulation of gene expression in prokaryotes: Operon model; lac operon, structure and regulation. Galactose operon; role of two promoters. Arabinose operon; positive control. Tryptophan operon; T attenuation control.

Eukaryotic gene regulation: Regulation of gene expression at the level of DNA structure; super coiling, DNA methylation. Role of nucleosome structure in enkaryotic gene expression; glucocorticoid gene, DNA kinking, bending and gene regulation. Chromatin structure, chromatin remodeling, Swi/Snf, remodeling assay, ChIP.

Unit-3:

Regulation at the level of transcription: Transcription factors, TF II, NFkB, regulation of NFkB and its activation. Formation of initiation complex. Role of enhancer.

Regulation at the level of RNA processing: RNA export and RNA stability, factors affecting RNA stability and RNA degradation.

Unit-4:

Regulation at the level of translation: Secondary structure in the 5' and 3' untranslated region; regulation of ferretin and transferring, mRNA. Role of upstream AUG codons. (GCN 4 gene regulation), transplanting and translational introns, protein splicing inteins.

Role of aminoacyl t-RNA synthetase in the regulation of accuracy of translation, proof reading mechanism. Ribosomal optimization of translation. Regulation at the level of ribosome assembly.

DNA binding protein motifs: Zinc finger, leucine zipper, helix-turn-helix and other motifs.

Regulation at the level of post translational modification: proteins stability, N-end rule, PEST and other sequences, unbiquitin mediated degradation.

Practical - 4: Experiments in Molecular biology-2 Credits

6 h/week

Objectives are:

- To study the techniques involved in manipulating DNA.

Course outcome, the student will:

- Understand the procedures involved in isolating nucleic acid from different biological sample.
- Understand the use and applications of different enzymes in manipulating nucleic acid using prokaryotes system.

Isolation of DNA and RNA from plant and animal source, purity of DNA

Assay of DNA, electrophoresis of DNA and RNA.

Preparation of media, culturing of transgenic *E.coli* and Yeast. Preparation competent cells.

Isolation of plasmids, ligation, transformation. Restriction digestion of DNA.

PCR: Primer design and amplification. RT-PCR, blotting.

Courses - Soft Cores

Project work - Soft core- 6 Credits

12 h/week

Objectives are:

- To address a small research problem.
- To design and interpret the results.

Course outcome, the student will:

- Understand designing experiments based on the research problem.
- Understand compiling and analyzing of data.

- Be able to write a comprehensive project report.

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

Seminar - Soft core - 4 Credits

8 h/week (Tutorial)

Objectives are:

- To train students for teaching
- To use teaching aids such as black board and Power point presentations

Course outcome, the student will:

- learn how to prepare his thoughts for lecturing
- learn how to prepare power point presentation effectively
- learn to interact effectively with the audience

Preparation of Power point presentation: The students shall learn to prepare effective slides using PPT. From the syllabus the students shall present three seminars in the form teaching using PPT or black board.

Paper Presentation: Presentation of a recently published research article in the broader field of Biochemistry from a peer reviewed Journal.

Genetic engineering - 3 Credits 48 h

Objectives are:

- To study the basics of recombinant DNA technology.
- To study the applications of various plasmids/vectors and PCR technique in cloning.
- To study the importance and applications of transgenic animals and plants.

Course outcome, the student will:

- Understand the principle and methodology employed in DNA recombinant technology.

- Understand the various plasmids/vectors in cloning.
- Understand the importance of restriction enzymes and ligation enzymes in the process of cloning.
- Understand the applications of transgenic animals, plants, gene therapy and their negative impact.

Unit-1:

Genetic Engineering: Extraction and purification of nucleic acids (DNA and RNA) from biological sources. Definition, aims and objectives of recombinant DNA technology, restriction-modification systems, restriction enzymes; type I, II and III, specificity, sticky ends and blunt ends, isoschizomers. Gene cloning; genomic cloning, shot gun cloning, cDNA cloning.

Unit-2:

Vectors: Plasmids, phage, cosmids and phagemid. Yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors, construction of expression vectors.

Ligation: Blunt end and sticky end ligation, use of linkers and adopters, homo polymer tailing, colony hybridization, plaque hybridization.

Transformation: Micro injection, electroporation, lipofection, calcium phosphate method, protoplast fusion/somatic cell hybridization and biolistic methods.

Transgenic plants and animals, gene knock out.

Unit-3:

Techniques: DNA sequencing, shot gun and orderly sequencing, chromosome walking, PCR; analysis of products, nested PCR, applications of PCR in cloning, agriculture and medicine. RT-PCR technique and applications. Real time PCR for quantification.

Identifying the right clones: Direct screening; insertional inactivation of marker gene, visual screening, plaque phenotype. Indirect screening; immunological techniques, hybrid arrest translation, hybrid select translation. Screening using probes; construction of gene probes, hybridization and labeling.

Unit-4:

Mapping in Prokaryotes and Viruses: Bacterial transformation and transduction, conjugation; F+ plasmids, Hfr cells, time of entry mapping. Arrangement of genes in phage chromosome, plaque formation and lytic cycle. Fine structure of rII locus of T4. Lysogeny and λ phage.

Applications: Gene therapy, applications in agriculture medicine, industry. GM foods, terminator gene, negative impact of genetic engineering.

Biotechnology - 3 Credits 48 h

Objectives are:

- To study the basics of microorganisms and its use in fermentation.
- To study the various factors governing the growth of microorganisms at laboratory scale and at industrial fermentation scale
- To study the methodology used in animal and plant cell culture.

Course outcome, the student will:

- Understand the principle and methodology employed in the growth of microorganisms
- Understand the various parameters affecting the growth of industrially important microorganisms.
- Understand the importance of plant and animal cell culture to produced therapeutically important secondary metabolites
- Understand the applications of industrial fermentors

Unit-1:

Historical Aspects: Discovery of microorganisms. Theory of spontaneous generation. Era of Louis Pasteur. Microbes and fermentation. Microbes and diseases Koch's Postulates.

General characteristics: morphology, nomenclature and classification of bacteria, yeast, molds, fungi actinomycetes, rickettesiae.

Techniques: Isolation and culture of microorganisms - aerobic and anaerobic culture methods, culture media. Isolation of pure colony, characterization. Staining - Gram stain acid fast, endospore, flagella.

Unit-2:

Microbial Nutrition: Factors influencing growth, growth curve of bacteria. Measurement of growth, continuous culture, synchronous culture chemostat. Auxotrophs, autotrophs, heterotrophs, methods of cultivations and preservation of microorganisms.

Methods of Control of Microorganisms: Bacteriostatic and bacteriocidal agents. Mechanisms of disinfection and sterilization. Physical and chemical methods.

Cell culture techniques: Introduction to plant and animal tissue/cell culture. Laboratory design, aseptic conditions, equipments and materials for cell culture. Different constituents of culture medium, types of media and their applications.

Unit-3:

Plant cell culture: Micro propagation, callus culture, haploid production, somatic embryogenesis, somatic hybridization, cybridization and somaclonal variation. Production of disease free plants.

Animal cell culture: Culture techniques, media, preparation of primary culture; disaggregation of tissue and primary cultures, chick embryo, HUVEC, characterization of cultures, ploidy, cell doubling time.

Unit-4:

Cell lines: Characteristics and routine maintenance, cell separation techniques. Measurement of viability and cytotoxicity. Scaling-up of animal cell culture; bioreactors used in animal cell culture, amplified cultures, continuous cultures and their applications.

Industrial applications: Fermentor; stirred fermentor, micro carrier, encapsulation, hollow fiber chambers, packed glass bead reactors. Cell immobilization techniques.

Characterization of the cultured cells, measuring parameters of growth. Cell synchronization, Somatic cell fusion, cell cloning and cryopreservation.

Applications of animal cell culture: Organ and histotypic cultures; three-dimensional culture, tissue engineering; example skin .

References

1. Nelson DL, Lehninger AL, Cox MM (2008) Lehninger principles of biochemistry: Macmillan.
2. Berg JM, Tymoczko JL, Stryer L (2006) Biochemistry: international edition: WH Freeman & Company Limited.
3. Voet D, Voet JG (1995) Biochemistry. New York: J. Wiley & Sons.
4. Wilson K, Walker J (2010) Principles and techniques of biochemistry and molecular biology: Cambridge University Press.
5. Cooper GM, Hausman RE (2000) The cell: Sinauer Associates Sunderland.
6. Alberts B, Bray D, Lewis J, Raff M, Roberts K, et al. (1995) Molecular Biology of the Cell (3rd edn). Trends in Biochemical Sciences 20: 210-210.
7. De Robertis ED, De Robertis EM (1981) Essentials of cell and molecular biology: Saunders College.
8. Lodish HF, Berk A, Zipursky SL, Matsudaira P, Baltimore D, et al. (2000) Molecular cell biology: WH Freeman New York.
9. Griffiths AJ (2005) An introduction to genetic analysis: Macmillan.
10. Halford NG (2003) Plant Biotechnology: The Genetic Manipulation of Plants: Adrian Slater, Nigel Scott, Mark Fowler; Oxford University Press, Oxford, New York, 346 pages, ISBN 0199254680, GBP 19.99. Pergamon.
11. Crueger W, Crueger A (2006) Biotechnology: a textbook of industrial microbiology.
12. Winnacker E-L (1987) From genes to clones: introduction to gene technology: VCH Verlagsgesellschaft.
13. Green MR, Sambrook J (2012) Molecular cloning: a laboratory manual.
14. Micklos DA, Freyer GA (1990) DNA science; a first course in recombinant DNA technology: Cold Spring Harbor Laboratory Press.
15. Primrose SB, Twyman R (2013) Principles of gene manipulation and genomics: John Wiley & Sons.
16. Walker M, Rapley R (2009) Route maps in gene technology: John Wiley & Sons.
17. Bryce C, Balasubramanian D (2004) Concepts in biotechnology: Universities Press.
18. Brown T (2010) Gene cloning and DNA analysis: an introduction: John Wiley & Sons.

19. Ayala FJ, Kiger JA (1980) Modern genetics: Benjamin/Cummings Publishing Company California.
20. Levin B (1999) Genes VII. Oxford University Press New York.
21. Watson JD (1970) Molecular biology of the gene. Molecular biology of the gene.