Department of Studies in Biochemistry
University of Mysore
Choice Based Credit System (2015 – 2016)

Department of Studies in Biochemistry offers 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 objective 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., 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.
- Students will be tested for their writing abilities to answer precise and essay type questions.
- Every semester the students will be subjected to viva voce examinations by external examiners
- Literature review in the form of Dissertation.
- Invited talks from eminent scientists.

Syllabus for M.Sc., 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 includes semester end examinations.

Credit Pattern of courses:

Hard Core: 3 – 6 Credits **Soft Core:** 2 – 4 Credits **Open elective:** 4 Credits

Project Work: 6 Credits **Dissertation:** 2 Credits

Credit Distribution of courses:

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

- A Candidate can enroll for a minimum of 18 Credits course per semester (First two semesters) and maximum of 24 Credits course per semester inclusive of Open Elective earned from the other Departments.
- 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:

Continuous Assessment	Time Duration	Marks		Minimum 30% and an aggregate of 40% to declare pass
		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 12 – 15 credits in a semester

Soft Core 36 Credits distributed as 8 – 11 credits in a semester

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

Semester	Hard Core	Soft Core	Open Elective	Total Credits	Minimum & Maximum
I	6 + 3 + 3 + 3 (15)	3 + 3 + 3 (9)	0	24 + 0	18 to 24
II	6 + 3 + 3 (12)	3 + 3 + 3 + 2 (11)	4	23 + 4	18 to 24
III	6 + 3 + 3 (12)	3 + 3 + 2 (8)	4	20 + 4	20 to 24
IV	3 + 4 + 6 (13)	3 + 3 + 3 + 2 (11)	4	24 + 4	20 to 24
Total	52	39	12	91 + 12	

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 (Minimum 18 and Maximum 24 credits)

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

II Semester (Minimum 18 and Maximum 24 credits)

Sl. No.	Code	Title of the course	Course Type	Credit pattern			Total Credits
				L	T	P	
1		Enzymology	HC	3	0	0	3
2		Amino acid and Protein Metabolism	HC	3	0	0	3
3		Practical- 2: Experiments in Enzymology and metabolism, seminar.	HC	0	2	4	6
4		Carbohydrate metabolism	SC	3	0	0	3
5		Lipid Metabolism	SC	3	0	0	3
6		Plant Biochemistry	SC	2	0	0	2
7		Dissertation	SC	0	0	2	2
8		Clinical Diagnosis in Health and Disease	OE	3	1	0	4

III Semester (Minimum 20 and Maximum 24 credits)

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

IV Semester (Minimum 20 and Maximum 24 credits)

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		Practical-4: Experiments in Molecular Biology and seminar	HC	0	2	2	4
3		Practical-5: Project Work	HC	0	0	6	6
4		Genetics and Gene regulation	SC	3	0	0	3
5		Genetic Engineering	SC	3	0	0	3
6		Biotechnology	SC	3	0	0	3
7		Biostatistics	SC	2	0	0	2
8		Clinical Diagnosis in Health and Disease	OE	3	1	0	4

I Semester Biochemistry

Courses - Hard Core

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

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. 12 h

Electrolytes, Non-Electrolytes and Electrodes: Osmotic pressure, vapor pressure, osmometer, Donnan membrane equilibrium. Hydrogen electrode, electrode potential, and redox potential. 6 h

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. 12 h

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. 12 h

Heterocyclic Compounds: Chemistry of furan, indole, thiazole, pterine, pteridine, isoalloxazine, pyrrole. Chemistry of porphyrins and heme and their biological importance. 6 h

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.

Preliminary techniques in Biochemistry: Animal and Plant models, choice of animals, types of studies, mutant organisms (auxotroph), animal and plant cell culture. 4 h

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. 5 h

Cell fractionation techniques: Cell lysis, homogenization, extraction, salting in, salting out, dialysis and ultra filtration. 3 h

Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium.

Ultra centrifugation: Differential and density gradient centrifugation, centrifugal elutriation. 6 h

Chromatographic techniques: Principles and applications of paper, TLC, adsorption, ion exchange, gel filtration, affinity, GLC, chromatofocusing, HPLC and FPLC. 10 h

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, glycoproteisn, lipoproteins, and nucleic acids. Zymogram and reverse zymogram. 8 h

Blotting techniques: Dot blot, Southern, Northern, Western blot, DNA foot print assay, DNA finger print assay, gel retardation assay, nuclease protection assay. RFLP, RAPD. 10 h

PCR, RT-PCR, Microarray. 2 h

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.

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications. 8 h

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. 12 h

X-ray Crystallography: Protein crystals, Bragg's law, unit cell, isomorphous replacement, fiber pattern of DNA. 4 h

Turbidometry, flame photometry, atomic absorption, spectrophotometry; instrumentation and applications. 6 h

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

Electrospray Ionization, fragmentation, m/e, time of flight, MALDI and ESI. LC-MS, LC-MS-MS. 6 h

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. 8 h

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. 4 h

Practical - 1: Biochemical techniques and Seminar 6 Credits

12 h/week (Practical and Tutorials)

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn the preparations of various laboratory reagents/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 laboratory reagents/solutions and their preparations with respect to percent solution, molar and normal solutions.

- Understand the 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 buffer, pH titration of amino acid, formal titration.

Preparation of cell homogenates; Prepration of chloroplast, mitochondria and nuclei.

Extraction of neutral lipids, phospholipids and estimation of phospholipids.

Iodine number, saponification value, acid value, peroxide value. TLC of lipids.

Separation of amino acids by ascending, descending, circular and 2D-paper chromatography. Descending paper chromatography of sugars.

Purification of polysaccharides (Starch and Glycogen)

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

Colorimetric and titrimetric estimation of sugars and proteins. Estimation of protein by Biuret and Lowry's methods. Estimation of sugar by DNS and anthrone methods.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic assigned.

Courses - Soft Core

Biomolecules - 3 Credits 48 h

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.

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

Chemistry of monosaccharides: 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. 8 h

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

Glycobiology: Glycoproteins; Glycosidic bond, N- and O-glycosylation, lectins, carbohydrates in tissue engineering. Proteoglycans; agreecan, syndecan, and decorin. Pectin and pectic polysaccharides. 6 h

Aminoacids: Nomenclature, classification and buffering properties, zwitterionic structure, reaction of amino acids, unusual amino acids, 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. 6 h

Determination of amino acid compositions: 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).

Elucidation of structure of proteins - Isolation of proteins; overview of purification and criteria of purity.

Determination of primary structure: Sequencing strategies; N-terminal and C-terminal, sequencing methods. Automated sequanators. Determiantion of s-s-bond position. Secondary structure of protein; α, β sheet, β bend, β turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm. Tertiary and quaternary structures. 10 h

Factors responsible for protein folding: Anfinsen's experiment. Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, allolysine, peptide bond, protein modification – glycosidic, phosphate, acetylation, methylation, hydroxylation and prenylation. Denaturation and renaturation of proteins, molten globule. 3D Structure of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Chaperons and Levinthal paradox. 6 h

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. 4 h

Nucleic Acids: Isolation of DNA and RNA from biological sources. Physiochemical properties of nucleic acids, melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA and RNA.5 h

Sequencing of DNA: Maxam Gilbert method, dideoxy method. Chargaff's rule, secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Secondary structure of tRNA and clover leaf model. Other secondary structural features in DNA, stem loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger, leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks. 8 h

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.

Biomembranes: Physicochemical properties of biological membranes; compositions, supra molecular organization. Models of membrane; Gorter and Grendel's experiment, bilayer structure, Danielle - Davson model of membrane. Evolution in concept of membrane models, Singer and Nicholson's model. Newer models. 10 h

Membrane asymmetry; lipids, proteins and carbohydrates and their lateral diffusion. Biogenesis of lipids and proteins, polarized cells, membrane domains; caveolae, rafts, membrane lipid and protein turnover, intracellular targeting of proteins. Biogenesis of sub cellular organelles. 8 h

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. 10 h

Physico-chemical properties of membranes: membrane lipid phases, bilayer phase, non bilayer phase, phase transition, membrane potential, bilayer nature. 4 h

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), bacterial phosphotransferase system. Endocytosis, receptor mediated endocytosis, exocytosis, ion channels; gated and non gated, aquaporin channel. 5 h

Nerve transmission: 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. 6 h

Muscle contraction: Mechanisms, role of calcium, calmodulin, phospholamban. 5 h

Physiology and Nutrition - 3 Credits 48 h

Objectives are:

- To study different systems operating in a living organisms.
- To study the Nutritional aspects essential for the healthy maintenance of a 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.
- Understand nutritional aspects of biomolecules such as carbohydrates, proteins, lipids, nucleic acid, minerals and vitamins.

Blood: Composition, cells, plasma proteins and lipoproteins. Erythrocytes; shape and function. WBC; types, differential count and functions. Platelets and its function. Buffer systems, hemostasis, blood clotting, digestion of clot, anticoagulants, blood volume, blood pressure and their regulations. Plasma lipoproteins and their functions, HDL, LDL, VLDL, chylomicrons.

Nervous system: Structure of a neuron, nerve transmission, CSF; composition and function. 6 h

Respiratory System: Lungs, structure and functions, gas exchange, oxygen binding by hemoglobin, factors affecting oxygenation and acid-base balance. 4 h

Excretory System: Ultra structure of the nephron, glomerular filtration, formation of urine, acid - base balance. 3 h

Hepatobiliary System: Anatomy of the liver, blood supply, cells; hepatocytes, endothelial cells and Kupffer cells, secretory and excretory function and formation of bile. 3 h

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. 4 h

Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins; actin, myosin, tropomyosine, troponins. 2 h

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. 7 h

Carbohydrates: Dietary sources, dietary fiber, essentiality of carbohydrates. 2 h

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. 4 h

Fats: Sources, invisible fat, essential fatty acids, PUFA. 2 h

Vitamins: Fat soluble and water soluble vitamins, provitamines, antivitamins, dietary sources, daily requirements, structure and function. Deficiency symptoms of B and C vitamins and fat soluble vitamins, hypervitaminosis, vitamin - like compounds. 4 h

Minerals: Macro and micro nutrients, sources, requirements, functions and deficiency symptoms. Water metabolism; distribution in body, water balances and factors affecting water balance. 4 h

Diet: Recommended daily allowances, special nutrition for infants, children, during pregnancy, lactation and old age. Nutrition for diabetes and cardiovascular disease patients. Wellness diets, fitness diets, obesity and BMI, 3 h

II Semester Biochemistry

Courses - Hard Core

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.
- Understand the nature of catalysis, mechanism of action and type of inhibition.
- Understand the regulation of enzymes in metabolic reactions.

General aspects: Nature of enzymes, localization, isolation, purification and characterization of 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. 8 h

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. 5 h

Rate of a reaction, order and molecularity. I order reaction kinetics. Rectangular hyperbola, Michaelis-Menten equation as rectangular hyperbola, linear transformation, calculation of slope, intercept. 4 h

Inhibition: Reversible and irreversible inhibition; competitive, non competitive, uncompetitive product inhibition and suicide inhibition.

Determination of Ki and Kd. 2 h

Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions. General rate equation. 2 h

Cooperativity: Binding of ligands to macromolecules; Scatchard plot, positive and negetive cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyltranscarbamylase as an allosteric enzyme. 5 h

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. 4 h

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. 4 h

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. 7 h

Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC). 4 h

Metabolic regulation of enzyme activity: Feedback regulation, fine control of enzyme activity. Fast reactions - Stopped flow, temperature jump method with examples of enzymes. 3 h

Amino acid and Protein metabolism - 3 Credits 48 h

Objectives are:

- To study the general pathways involved in protein degradation.
- To study amino acid metabolism, intermediate metabolism and its regulation

Course outcome the student will:

- Understand biosynthesis and degradation of proteins, glycoprotesins, proteoglycans, heme and porphyrins.
- Understand biosynthesis of non-ribosomal synthesis of peptides and physiological active amines.
- Understand general mechanism of amino acid metabolism, intermediate metabolism and its regulations in microorganisms, plants and animals.

Proteins: General mechanisms of degradation in cells; ubiquitin-proteosome pathway, lysosomal pathway. 4 h

Degradation and biosynthesis of glycoproteins and proteoglycans. 4 h

Degradation and Biosynthesis of heme and porphyrins. 4 h

Non ribosomal peptide synthesis: glutathione, gramicidine. 4 h

Biosynthesis of physiologically active amines; serotonin, histamine, dopamine, norepinephrine and epinephrine. 6 h

General mechanisms of amino acid metabolism and regulations: Role of cofactors; PLP and THF in amino acid metabolism. Deamination, transamination, decarboxylation desulphuration process. 4 h

Degradation and biosynthesis of individual ammo acids. Aliphatic, aromatic, and branched chain amino acids. 6 h

Differences in the pathways in microorganisms, plants and animals. 2 h

Intermediatory metabolism: Ketogenic and glucogenic amino acids. 4 h

Regulation of amino acid biosynthesis; transglutaminase cycle, urea cycle. 6 h

In born errors of amino acid degradation; PhenylKetonuria, alkaptonuria, maple syrup urine. 4 h

Practical - 2: Experiments in Enzymology and Metabolism and Seminar. 6 Credits

12 h/week (Practical and Tutorials)

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.
- To develop skills for seminar presentation.

Course outcome the student will:

- Understand the estimation of proteins by different colorimetric methods

- Understand different enzyme assays with respect to specific activity, Km, Vmax and effect of pH, temperature and substrates.
- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Protein assays: 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.

Photo-oxidation of methylene blue.

Photosynthetic reduction of 2,6 dichlorophenolindophenols.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic from the subjects assigned.

Courses - Soft core

Carbohydrate metabolism - 3 Credits 48 h

Objectives are:

- To study different aspects of catabolism, anabolism and amphibolic pathways of carbohydrate metabolism
- To study the synthesis of high energy compounds in the cell, energy utilization and disorders of carbohydrate metabolism.

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.

Introduction - Catabolism, anabolism, and amphibolic pathways. 2 h

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. 12 h

Hormonal regulation of glucose 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 etc.,)

Disorders of carbohydrate metabolism: diabetes mellitus, classification and clinical diagnosis. 10 h

Energy Utilization: I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium. 2 h

High energy compounds: Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound. 3 h

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. 10 h

ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. 7 h

Substrate level phosphorylation, futile cycles and their application. 2 h

Lipid Metabolism - 3 Credits 48 h

Objectives are:

- To study lipid synthesis and its degradation.
- To study Lipid metabolism, intermediate metabolism and its regulation

Course outcome the student will:

- 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.

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. Regulatory aspects. 10 h

Oxidation: α , β and ω oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachiodnante. Regulatory aspects. 10 h

Cholesterol synthesis, degradation, and regulations, cholesterol lowering drugs: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse

cholesterol transport by HDL. Oxidized lipids and their metabolism, Mechanism of foam cell formation. Obesity, and mechanisms, exercise and regulation of energy metabolism. 10 h

Phospholipid biosynthesis and regulations: Denovo pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Degradation and biosynthesis of gangliosides and cerebrosides. Biosynthesis of prostaglandins, thromboxanes, leukotrienes, and lipoxins. 10 h

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG, ceramide and PAF. 5 h

Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation. 3 h

Plant Biochemistry - 2 Credits 32 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.

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. 6 h

Nitrogen metabolism: Importance of nitrogen in biological systems, nitrogen cycle. Nitrogen fixation; symbiotic and nonsymbiotic, nitrogenase complex, energetics

and regulation. Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion. 4 h

Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and mechanisms of action of auxines, gibberlines, cytokinins, ethylene, abscisic acid. 2h

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. 2h

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. 6 h

Phytochemicals: Extraction, fractionation and characterization. 2 h

Secondary metabolites - Terpenes, phenols, flavonoids and nitrogenous compounds and their roles in plant physiology and as alternative medicine. 4 h

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. 3 h

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in plants, cell-cell fusion in both normal and abnormal cells and defense system in plants. 3 h

Courses - Dissertation: 2 Credits

Objectives are:

- To study and consolidate a research problem by collecting the available research data.

Course outcome the student will:

- Be trained to review literature of a research problem.
- Understand the research problem so that one can plan for future course of the research work.

Dissertation: Students will be assigned/they will select a recent topic on which they will write a review and submit in the form of a booklet for evaluation.

Courses - Open Elective (II and IV Semesters; Even)

Clinical Diagnosis in health and diseases - 4 Credits (3L + 1T) 48 h

Objectives are:

- To study the basics of health and disease conditions.
- To study clinical investigations for diagnosis and their awareness.

Course outcome the student will:

- Understand general health and disease state.
- Understand the difference between communicable diseases and non-communicable disease and precautionary measures to prevent the same.
- Understand different laboratory investigation procedures involved in diagnosis.

Introduction: General health, syndrome and common diseases – communicable and non-communicable diseases. 3 h

Samples for analysis: Blood, urine, pleural fluid, synovial fluid, cerebrospinal fluid and tissues and histology. 3 h

General check up: Blood group, Hb, height and weight, waist to hip ratio, electro cardio gram, X-ray, abdomen scan and appearance of scars, urine analysis – routine analysis (protein, sugar, pigments and cells). 6 h

Special test – detection of metabolites and its importance.

Tests for liver function: Enzyme assay (SGOT, SGPT, Alkaline phosphatase, GGT), Total protein, albumin / globulin ratio and their significance. 3 h

Test for kidney function: Urea and creatinine estimation and their significance. 2 h

Test for heart function: Blood pressure (cystolic and diastolic), lipid profile (cholesterol, triglycerides, HDL, LDL estimation) and their importance. 4 h

Test for lung function: Chest X-ray, Spirometry.

Test for Brain function: EEG, MRI, CT.

Test for Surgery: Bleeding time, clotting time.

Infection: Bacterial, viral, fungal and protozoans.

Blood: Total cell count, differential count, erythrocyte sedimentation rate. 7 h

Infectious diseases: Tuberculosis, Leprosy, Malaria, Hepatitis, Cholera, Dengue, HIV, Chikun gunya and H1N1. TORCH – Panel (infertility profile), Infection in pregnancy, Koch postulations - Microscopic examination of body fluids, ELISA and PCR tests. 7 h

Non communicable diseases:

Diabetes: Blood sugar, urine sugar, glucose tolerance test, HbA1c.

Hyper tension: Lipid profile, electrolyte (sodium, potassium, chloride and biocarbonate) investigation. 4 h

Special test: X-ray, CT, MRI, Doppler, TMT, angioplasty.

Cancer markers: ELISA. 3 h

Professional hazard: High risk groups

(Farmers, heavy duty machine workers, CEOs, athletes).

Doping in sports:

Drug addition: 6 h

Tutorials: Discussion, demonstration, laboratory visits

III Semester Biochemistry

Courses - Hard Core

Immunology - 3 Credits 48 h

Objectives are:

- To study the basics of defense system with respect to innate immunity.
- To study cellular and humoral bases of immunity.
- To study Immune responses in autoimmunity, tumor environment, transplantation and immune deficiency.
- To study immunological techniques and their employment to diagnose disorders.

Course outcome the student will:

- Understand the primary and secondary immune responses in cell mediated responses and production of cytokines and co-stimulatory molecules.
- Understand the basics involved in cell mediated and humoral mediated defense mechanism.
- Understand the molecular/biochemical process involved in the development of autoimmune diseases and tumor, transplantation and hypersensitive reactions.

Introduction: Historical development and milestones in immunology. Definitions; antigenicity, immunogenicity, innate and acquired 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. 8 h
Classes and subclasses of immunogloblins, structure of immunoglobulins, hyper variable region isotypic, allotypic and idiotypic variation. 4 h

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. 10 h

MHC: MHC gene and its polymorphism, role of MHC in immune response and transplantation. 3 h

Non-specific defenses in man: Barriers to infection; skin, mucous membrane, inflammation, complement hyper sensitivity reactions (Type I, II, III and IV). 4 h

Transplantation: Autograft, isograft, allograft and xenograft. Graft rejection, graft vs. host reaction. Immunosuppressive drugs. 3 h

Tumour immunology: Tumour associated antigens, factors favoring tumour growth, immune surveillance. Tumour necrosis factor α and β. Antitumour drugs. 3 h

Disorders of immunity: Immunological tolerance, auto immune disorders, AIDS, SCID. Systemic Lupus Erythomatosus. 4 h

Vaccines: Adjuvants, vaccines and their preparations. Polyclonal and monoclonal antibodies; hybridoma technique. 3 h

In vitro antigen-antibody reaction: Precipitation, agglutination, complement fixation, immuno diffusion, immunoelectrophoresis, immunofluorescence, RIA, ELISA. 6 h

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, lipids 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.

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. 8 h

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. 6 h

Functions and abnormalities: Hypo and hyper production of hormones secreted by; pituitary, thyroid, pancreas, adrenals and gonads. 3 h

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. 6 h

Regulation of hormone production and release: hypothalamus-pituitary-target organ axis and regulation by feedback mechanism. 2 h

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. 8 h

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. 6 h

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. 4 h

Pineal gland, melotonin and circadian rhythm.

Chemistry and action of prostaglandins, prostacyclins and thromoxanes. 3 h

Newly discovered hormones

Insect hormones: Structure and function of moulting hormone, ecdysone, juvenile hormones, Pheromones. Application of insect hormones. 2 h

Practical - 3: Experiments in Immunology and Clinical Biochemistry and Seminar 6 Credits

12 h/week (Practical and Tutorials)

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn the assays of clinically significant serum enzymes.
- To learn immunological assays from chicken egg yolk immunoglobulins.
- 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 in biological sample.
- Understand the different functional analysis such as lipid profile, diabetes profile, liver and kidney profile.
- Understand the structure and characteristics of immunoglobulins using various immunological techniques.
- 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, Postprandial blood sugar, GTT by GOD and POD method.

Renal function test: Urea and creatinin.

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

Gout: Uric acid

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

Seminar: Each student will give a 15 min seminar with power point presentation on a topic from the subjects assigned.

Courses - Soft core

Nucleic Acid Metabolism - 3 Credits 48 h

Objectives are:

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

Course outcome the student will:

- Understand the detailed synthesis of purines and pyramidines pathways and its disorders.
- Understand the mechanism of photosynthesis and other nitrogen fixation process.

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. 14 h

Gout and Lysch-Nyhan syndrome. Conversion of nucleotides to deoxynuclotides. Mchanisms of action of methotrexate, 5-fluorouridine, azathymidine. 6 h

Biosynthesis of cofactors: NAD^+, FAD and coenzyme A, polyamine biosynthesis and their metabolic role. 8 h

Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. Electron flow and phosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C3, C4 and CAM cycle. Photorespiration, bacterial photosynthesis. Regulation of photosynthesis. RUBISCO. 12 h

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. 8 h

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.

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. 4 h

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

Anemias; microcytic, normocytic and macrocytic. 4 h

Diagnostic enzymology: Clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatine kinase and LDH. 4 h

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. 4 h

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. 5 h

Kidney: Assessment of renal function; creatine clearance, renal calculi, uremia, laboratory investigation of kidney disorders. 4 h

Gastrointestinal disorders: Fractional gastric analysis, hypo and hyper acidity, gastric ulcers, malabsorption syndrome, steatorrhea and diarrhoea. 3 h

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. 11 h

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

Cardiovascular disorders: Major Cardio vascular system, atherosclerosis, risk factors and pathogenesis. Diagnosis and prognosis. 4 h

Cancer: Etiology, diagnosis, treatment and prognosis. Carcinogens, oncogens, mechanism. Biochemistry of ageing: Cellular senescence, cystic fibrosis. Mechanism of detoxification of xenobiotics. 5 h

Genomics, Proteomics and Bioinformatics - 2 Credits 24 h

Objectives are:

- To study the basics of genomics, proteomics through bioinformatics.
- 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 and protein sequences.
- Understand the generation and prediction of different molecular structural modeling from the available data.

- Understand molecular phylogenetic based on the existing sequence data.
- Understand proteomics and sequence analysis using various software.
- Understand designing a drug and its interaction with the ligands.

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. 2 h

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). 2 h

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. ucleotide sequence analysis, tools and methods, single nucleotide polymorphism. 3 h

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. 2 h

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. 3 h

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. 2 h

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. 3 h

Protein modeling: Introduction, methods of protein modeling, homology or comparative modeling, model refinement, evaluation of the model. 1 h

Molecular modeling: Concepts of Molecular Modeling, molecular structure and internal energy, energy minimization of small molecules, *Ab initio*, and semi-empirical methods, Construction of initial model, refining the model, manipulating the model, three-dimensional structure prediction, comparative modeling, homology modeling, threading, energy based prediction of protein structures, modeling software. 3 h

Introduction to drug designing: In silico analysis, physico-chemical property prediction, aqueous solubility, Lipinski's rule of five.

Docking methods: Three dimensional descriptions of binding site environment and energy calculation, automatic docking method. Three dimensional database search approaches, design of ligands, drug-receptor interactions, automated structure construction methods, AUTODOCK. 3 h

Courses - Open Elective (III Semester; Odd)

Fundamentals of Biochemistry - 4 Credits (3L + 1T) 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.

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. 6 h

Respiratory System: Lungs, structure and functions, exchange of gases, 2 h

Excretory System: Ultra structure of the nephron, formation of urine. 2 h

Hepatobiliary System: Anatomy of the liver, cells types.. Secretory and excretory function and formation of bile. 3 h

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Function of HCl 3 h

Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins; 2 h

Nutrition: Small molecules: sugars, amino acids, nucleotides, lipids. Macromolecules: polysaccharides, proteins, nucleic acids. 4 h

Carbohydrates: Dietary sources, dietary fiber, essentiality of carbohydrates. 2 h

Proteins: Essential amino acids, nutritional classification of proteins, supplementary value of proteins, protein malnutrition. 2 h

Fats: Sources, invisible fat, essential fatty acids, PUFA. 2 h

Vitamins: Classification, source, deficiency symptoms Fat soluble and water soluble vitamins. 6 h

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. 4 h

Implications in health and disease: Diabetes Hyper tension, Hypotension Gouti arthritis, 4 h

Immunology: Historical development and milestones in immunology Vaccines and Vaccination. 3 h

Toxicity: Xenobiotics, heavy metals, pesticide poisoning. 3 h

Tutorials: Discussion, demonstration, laboratory visits.

IV Semester Biochemistry

Courses - Hard Core

Molecular biology - 3 Credits 48 h

Objectives are:

- To study the basics of molecular biology.
- To study the molecular mechanism involved in the storage and transfer of genetic 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.

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. 4 h

DNA-antiparellel nature: Nearest neighbour base frequency analysis. Replication of DNA, semi conservative nature; Messelson and Stahl experiment. Replication of double stranded DNA, direction of replication, discontinuous replication, Okazaki fragements. DNA polymerase I II and III, DNA ligase, DNA topoisomerases. 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). 10 h

Transcription: Colinerity of genes and proteins, RNA polymerase I, II and III. RNA biosyntehsis in prokaryotes and eukaryotes; initiation, 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. 10 h

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. 10 h

3D structure of prokaryotic and eukaryotic ribosomes, ribosomal protein synthesis; initiation elongation and termination. Role of mRNA and tRNA. Aminoacyl tRNA synthesis and its role in translation accuracy. 10 h

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

Enzymes in DNA and RNA degradation: Nucleases, ribonucleases, classification and role. 4 h

Practical - 4: Experiments in Molecular biology, and Seminar

4 Credits

6 h/week (Practical and Tutorials)

Objectives are:

- To study the techniques involved in manipulating DNA.
- Presentation of a recently published research article.

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 prokaryotic system.
- Understand the latest information published in the Journals.

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 of competent cells.

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

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

Paper Presentation: Presentation of recent Research Article published in the last two years which is appropriate in the various disciplines of Biochemistry from a peer reviewed Journal.

Practical - 5: Project work 6 Credits

12 h/week (Practical)

Objectives are:

- To address a small research problem.
- To design, perform 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, perform experiments, generating results, analysis of results and writing a comprehensive project report.

Courses - Soft Core

Genetics and 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.

Basic Principles of Mendelism: Laws of inheritance, dominance, codominance, epistasis, (coomb shape in chickens) pleiotropism. Cytoplasmic inheritances (male sterility in plants, shell coiling). 2 h

Gene linkage and chromosome: Linkage and recombination of genes in a chromosome. X-linked inheritance. Polygenic inheritance, mitochondrial inheritance, Y-chromosome inheritance. Map unit. 2 h

Chromosome number: Ploidy, Karyotyping, sex chromosome and dosage compensation. Mobile genetic elements. 2 h

Molecular Genetics: Mutations; nature of mutations, spontaneous and induced mutation, conditional, lethal (temperature sensitive) mutation. Biochemical basis of mutation. Point mutation, base substitution mutation, missense, nonsense and silent mutation. Mutation rates. Chemical mutagens, radiation induced mutation, reverse mutations and suppressor mutations - intergenic and intragenic suppression, reversion as a means of detecting mutagens - Ames test. 6 h

Repair Mechanism: Reciprocal recombination, site specific recombination, Ecoli rec system. Holliday model of recombination. 3 h

Chromosomal Basis of Human Diseases: Extra or missing chromosome, abnormality in chromosome structure; deletion, duplication, inversion, translocation. 3 h

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. 6 h

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. 6 h

Regulation at the level of transcription: Transcription factors, TF II, NFkB, regulation of NFkB and its activation. Formation of initiation complex. Role of enhancer. 4 h

Regulation at the level of RNA processing: RNA export and RNA stability, factors affecting RNA stability and RNA degradation. 4 h

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. 6 h

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. 2 h

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, ubiquitin mediated degradation. 2 h

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 in prokaryotes and eukaryotes.
- Understand the various vectors and other molecular tools in cloning.
- Understand the applications of transgenic animals, plants, gene therapy and their negative impact.

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. 10 h

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. 10 h

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. 10 h

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. 10 h

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. 4 h

Applications: Gene therapy, applications in agriculture medicine, industry. GM foods, terminator gene, negative impact of genetic engineering. 4 h

Biotechnology - 3 Credits 48 h

Objectives are:

- To study the early discoveries in the field of conventional biotechnology and progress made in modern biotechnology.
- To study the various culture techniques employed for prokaryotic and eukaryotic cell culture.
- To study the industrial applications of fermentation techniques.

Course outcome the student will:

- Understand the isolation, characterization of microorganisms used in conventional and modern biotechnology.
- Understand various types of sterilization techniques, different fermentors and various factors affecting the microbial growth.
- Understand the preparation of primary animal cell culture and callus culture of plant tissue culture.
- Understand the industrial production of biomolecules by fermentation technique.

Historical Aspects - Discovery of microorganisms. Theory of spontaneous generation. Era of Louis Pasteur. Microbes and fermentation. Microbes and diseases Koch's Postulates. 2 h

General characteristics: morphology, nomenclature and classification of bacteria, yeast, molds, fungi actinomycetes, rickettesiae. 5 h

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. 5 h

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. 5 h

Methods of Control of Microorganisms - Bacteriostatic and bacteriocidal agents. Mechanisms of disinfection and sterilization. Physical and chemical methods. 5 h

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. 4 h

Plant cell culture: Micro propagation, callus culture, haploid production, somatic embryogenesis, somatic hybridization, cybridization and somaclonal variation. Production of disease free plants. 4 h

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. 4 h

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. 6 h

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 . 8 h

Biostatistics - 2 Credits 32 h

Objectives are:

- To study the sampling techniques for biostatistics analysis.
- 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.

Introduction to Biostatistics: Population, sample, sampling techniques, random sample. 4 h

Mean, median, mode, range, variance, coefficient of variation, frequency, standard deviation, standard error. Representation of statistical data line graph, histogram, bar diagram, pie chart, scatter diagram. 8 h

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. 8 h

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. 8 h

X2 test: goodness of fit, test of independence.

Non parametric statistics, sign test, rank sum test, rank correlation. 4 h

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