

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

The Choice Based Credit System (CBCS) comprises Hard Core, Soft Core subjects for Biochemistry Students and Open Elective for students other than Biochemistry. Following shall be the minimum and maximum subjects 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:

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

**Project Work:** 6 Credits

**Dissertation:** 2 Credits

**Credit Distribution:**

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 per semester (First two Semester) and maximum of 24 Credits 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:

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

**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

I Semester: (6 + 3 + 3 + 3) (3 + 3 + 3) (0) = (24 + 0 = 24) (18 to 24)

II Semester: (6 + 3 + 3) (3 + 3 + 2) (4) = (20 + 4 = 24) (18 to 24)

III Semester: (6 + 3 + 3) (3 + 3 + 2) (4) = (20 + 4 = 24) (20 to 24)

IV Semester: (6 + 4 + 3) (3 + 3 + 3 + 2) (4) = (24 + 0 = 24) (20 to 24)

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 + 2 (8)	4	20 + 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	36	12	88 + 12	

**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 Paper	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 Paper	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 and Dissertation.	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	3	0	0	3
7		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 Paper	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 Paper	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

## Hard Core

### **Bioorganic and Bioinorganic Chemistry - 3 Credits** **48 h**

**Bonding:** Covalent bond; coordinate bond; coordinate bond formation in transition metals. Bonding of iron in hemoglobin and cytochromes, cobalt in Vit B<sub>12</sub>, 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, stereoisomer, 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**

**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, glycoproteins, 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**

**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:**  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{32}\text{P}$ ,  $^{131}\text{I}$ ,  $^{35}\text{S}$ , 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)**

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

Preparation of cell homogenates; Preparation 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.

## **Soft Core**

### **Biomolecules - 3 Credits**

**48 h**

**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; aggrecan, 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, enkephalins 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 sequencers. Determination of s-s-bond position. Secondary structure of protein;  $\alpha$ ,  $\beta$  sheet,  $\beta$  bend,  $\beta$  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. Physicochemical properties of nucleic acids, melting of DNA,  $T_m$ ; factors affecting  $T_m$ , 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**

**Biomembranes:** Physicochemical properties of biological membranes; compositions, supra molecular organization. Models of membrane; Gorter and Grendel's experiment, bilayer structure, Danielli - 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<sup>2+</sup> ATPase, Na<sup>+</sup>-K<sup>+</sup> 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**

**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 HCl 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

## Hard Core

### Enzymology - 3 Credits

48 h

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.  $V_{max}$ ,  $K_m$  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  $K_i$  and  $K_d$ . 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 negative 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<sup>+</sup>, 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**

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 amino acids. Aliphatic, aromatic, and branched chain amino acids. 6 h

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

Intermediary 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, Seminar and Dissertation.** **6 Credits**

**12 h/week (Practical and Tutorials)**

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,  $K_m$  and  $V_{max}$ .

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.

**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.

## Soft core

### **Carbohydrate metabolism - 3 Credits**

**48 h**

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
<b>Energy Utilization:</b> I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium.	2 h
<b>High energy compounds:</b> Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound.	3 h
<b>Mitochondrial electron transport:</b> 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**

Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; lipase, hormone sensitive lipase, phospholipases and sphingomyelinase. Fatty acid degradation;  $\beta$ -oxidation Knoop's experiment, saturated and unsaturated fatty acids. Regulatory aspects. 10 h

Oxidation:  $\alpha$ ,  $\beta$  and  $\omega$  oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachidonic acid. 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 cerebroside. Biosynthesis of prostaglandins, thromboxanes, leukotrienes, and lipoxins. 10 h

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thromboxanes, 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 - 3 Credits**

**48 h**

**Photosynthesis:** Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. Electron flow and photophosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C<sub>3</sub>, C<sub>4</sub> and CAM cycle. Photorespiration, bacterial photosynthesis. Regulation of photosynthesis. RUBISCO. 8 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. 6 h

**Plant hormones:** Biosynthesis, storage, breakdown and transport. Physiological effects and mechanisms of action of auxines, gibberellins, cytokinins, ethylene, abscisic acid. 4 h

**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. 4h

**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. 8 h

Phytochemicals: Extraction, fractionation and characterization. 4 h

**Secondary metabolites** - Terpenes, phenols, flavonoids and nitrogenous compounds and their roles in plant physiology and as alternative medicine. 6 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. 4 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. 4 h

## **Open Elective (II and IV Semesters; Even)**

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

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

## Hard Core

### Immunology - 3 Credits

48 h

**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-1 $\beta$ , IL-2, TNF $\alpha$ . 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  $\alpha$  and  $\beta$ . 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**

**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, melatonin and circadian rhythm.

Chemistry and action of prostaglandins, prostacyclins and thromboxanes. 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)**

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.

## Soft core

### **Nucleic Acid Metabolism - 3 Credits**

**48 h**

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 deoxynucleotides. Mechanisms of action of methotrexate, 5-fluorouridine, azathymidine. 6 h

Biosynthesis of cofactors: NAD<sup>+</sup>, 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. C<sub>3</sub>, C<sub>4</sub> 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**

**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.

Disorders; graves disease, Hashimoto disease, Addison'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; prehepatic, hepatic and post hepatic.

Diseases of the liver - Hepatitis cholestasis, cirrhosis, 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, alcapton urea. Lesch-Nyhan, Gout. Diagnosis of metabolic disorders, Amniocentesis.

Disorders of carbohydrate metabolism; diabetes mellitus, classification, etiology, management. Laboratory investigations; GTT, HbA1c, 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 lipoproteinemia 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**

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

**Molecular phylogenetics:** Introduction, application of phylogenetic trees, basic terminology, taxa, taxonomy, root, leaf, node, tree, branch, clade, dendrogram, 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

### **Open Elective (III Semester; Odd)**

#### **Fundamentals of Biochemistry - 4 Credits (3L + 1T) 48 h**

**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

## Hard Core

### **Molecular biology - 3 Credits**

**48 h**

**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-antiparallel 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 fragments. 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 biosynthesis in prokaryotes and eukaryotes; initiation, elongation and termination. RNA dependent RNA synthesis, RNA replicase of Q $\beta$  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)**

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.

**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)**

Project work will be on defined research topic allotted to the students. The students will also have to present a research data paper published recently in peer reviewed journals preferably in the area of project work.

## Soft Core

### **Genetics and Gene Regulation - 3 Credits      48 h**

**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 ferritin and transferrin, mRNA. Role of upstream AUG codons. (GCN 4 gene regulation), transcribing 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**

**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 adaptors, 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  $\lambda$  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**

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, rickettsiae. 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**

**24 h**

**Introduction to Biostatistics:** Population, sample, sampling techniques, random sample. 2 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. 6 h

**Collection of data:** Relevance of sample size. Sources, methods-questionnaires, records, archives, scaling-Likert and Gutman. Validation and standardization of the methods, modification and experimental design. 6 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. 7 h

**X<sup>2</sup> test:** goodness of fit, test of independence.

Non parametric statistics, sign test, rank sum test, rank correlation. 3 h

## 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. Ege 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. Devlin TM (2011) Textbook of biochemistry: with clinical correlations.
14. Voet D, Voet JG (1995) Biochemistry. New York: J. Wiley & Sons.

15. Zuby G (1988) *Biochemistry*, 236 New York. MacMillan.
16. Smith EL (1983) *Principles of biochemistry: mammalian biochemistry*: McGraw-Hill Companies.
17. Chatterjee CC (1951) *Human physiology*: Medical Allied Agency.
18. Murray R, Granner D, Mayes P, Rodwell V (2003) *Harper's illustrated biochemistry (LANGE basic science)*: McGraw-Hill Medical.
19. Purohit S, Mathur S (1999) *Drugs in Biotechnology fundamentals and applications*. Purohit SS. Maximillan publishers, India.
20. Guyton Aurcher C, Hall John E (2006) *Text book of Medical Physiology*. Elsevier India Pvt. Ltd. New Delhi.
21. Dixon M, Webb E (1979) Enzyme inhibition and activation. *Enzymes* 3: 126-136.
22. Rao C (1973) *University General Chemistry: An Introduction to Chemical Science*: MacMillan India.
23. Wilson K, Walker J (2010) *Principles and techniques of biochemistry and molecular biology*: Cambridge University Press.
24. Pigman W (2012) *The carbohydrates: chemistry and biochemistry*: Elsevier.
25. Marshall AG (1978) *Biophysical chemistry: principles, techniques, and applications*: Wiley New York.
26. Fersht A (1985) *Enzyme structure and mechanism*.
27. Price NC, Frey PA (2001) Fundamentals of enzymology. *Biochemistry and Molecular Biology Education* 29: 34-35.
28. Palmer T, Bonner PL (2007) *Enzymes: biochemistry, biotechnology, clinical chemistry*: Elsevier.
29. Rawn J (1989) *Biochemistry—International edition*. North Carolina: Neil Patterson Publishers.
30. Dey PM, Harborne JB (1997) *Plant biochemistry*: Academic Press.
31. Goodwin TW, Mercer EI (1983) *Introduction to plant biochemistry*.
32. Buchanan BB, Gruissem W, Jones RL (2000) *Biochemistry & molecular biology of plants*: American Society of Plant Physiologists Rockville.
33. Singhal G (1999) *Concepts in photobiology: photosynthesis and photomorphogenesis*: Springer Science & Business Media.

34. Murray RK, Gurner D, Mayes PA (1996) Harper's biochemistry: London: Prentice Hall International, 1996.
35. Conn E, Stumpf P (2009) Outlines of biochemistry: John Wiley & Sons.
36. Delves PJ, Martin SJ, Burton DR, Roitt IM (2011) Roitt's essential immunology: John Wiley & Sons.
37. Weir DM (1967) Handbook of experimental immunology. Handbook of experimental immunology.
38. Owen JA, Punt J, Stranford SA, Jones PP (2013) Kuby immunology: WH Freeman New York.
39. Abbas AK, Lichtman AH, Pillai S (2014) Cellular and Molecular Immunology: with student consult Online Access: Elsevier Health Sciences.
40. Cooper GM, Hausman RE (2000) The cell: Sinauer Associates Sunderland.
41. 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.
42. De Robertis ED, De Robertis EM (1981) Essentials of cell and molecular biology: Saunders College.
43. Lodish HF, Berk A, Zipursky SL, Matsudaira P, Baltimore D, et al. (2000) Molecular cell biology: WH Freeman New York.
44. Pelczar MJ, Chan ECS, Krieg NR, Edwards DD, Pelczar MF (1993) Microbiology: concepts and applications: McGraw-Hill New York.
45. Prescott SC, Dunn CG (1949) Industrial microbiology. Industrial microbiology.
46. Salle AJ (1984) Fundamental principles of bacteriology: Tata McGraw-Hill Education.
47. Griffiths AJ (2005) An introduction to genetic analysis: Macmillan.
48. 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.
49. Crueger W, Crueger A (2006) Biotechnology: a textbook of industrial microbiology.
50. Winnacker E-L (1987) From genes to clones: introduction to gene technology: VCH Verlagsgesellschaft.

51. Green MR, Sambrook J (2012) Molecular cloning: a laboratory manual.
52. Moore TC (1979) Biochemistry and physiology of plant hormones: Springer-Verlag.
53. Latner AL, Hall R, Besser GM (1975) Cantarow and Trumper clinical biochemistry: WB Saunders.
54. Smith CM, Marks AD, Lieberman M (2005) Basic Medical Biochemistry: A Clinical Approach: Lippincott Williams & Wilkins.
55. Cohen NC (1996) Guidebook on molecular modeling in drug design: Academic Press.
56. Branden CI (1999) Introduction to protein structure: Garland Science.
57. Creighton TE (1993) Proteins: structures and molecular properties: Macmillan.
58. Cseke LJ, Kirakosyan A, Kaufman PB, Westfall MV (2011) Handbook of molecular and cellular methods in biology and medicine: CRC press.
59. Micklos DA, Freyer GA (1990) DNA science; a first course in recombinant DNA technology: Cold Spring Harbor Laboratory Press.
60. Primrose SB, Twyman R (2013) Principles of gene manipulation and genomics: John Wiley & Sons.
61. Walker M, Rapley R (2009) Route maps in gene technology: John Wiley & Sons.
62. Bryce C, Balasubramanian D (2004) Concepts in biotechnology: Universities Press.
63. Brown T (2010) Gene cloning and DNA analysis: an introduction: John Wiley & Sons.
64. Kornberg A, Baker TA (1980) DNA replication: WH Freeman San Francisco.
65. Ayala FJ, Kiger JA (1980) Modern genetics: Benjamin/Cummings Publishing Company California.
66. Levin B (1999) Genes VII. Oxford University Press New York.
67. Watson JD (1970) Molecular biology of the gene. Molecular biology of the gene.