Department of Studies in Biochemistry, Manasagangotri, Mysore
BIOCHEMISTRY, CHOICE BASED CREDIT SYSTEM,(2013-14)

I SEMESTER BIOCHEMISTRY

Hard core papers

Biochemical techniques - 3 credits 45 h

Preliminary techniques in Biochemistry: Animal models, choice of animals, types of studies, mutant organisms (auxotroph), cultured animal and plant cells and plant as models. 2 h

Cell fractionation techniques: Cell lysis, homogenization, extraction, salting in, salting out, dialysis and ultra filtration. 2 h

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

Ultra centrifugation: Differential and density gradient centrifugation, centrifugal elutriation, construction of preparative and analytical ultra centrifuge, Schleiran optics. 6 h

Chromatographic techniques: Principles and applications of paper, TLC, adsorption, ion exchange, gel filtration, affinity, GLC, chromatofocusing, HPLC and FPLC. 8 h

Electrophoretic techniques: Polyacrylamide gel electrophoresis, SDS-PAGE, 2D-electrophoresis, agarose gel electrophoresis, isoelectric focusing, pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis, isotachophoresis. Separation of proteins, lipoproteins and nucleic acids. Visualizing separated components; staining, fluorescence, PAS staining, zymogram and reverse zymogram. 6 h

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications. 4 h

Isotopic tracers: Heavy isotopes and radio isotopes, theory and construction of mass spectrometer. Ionization, fragmentation, m/e, time of flight, MALDI and ESI. 4 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

Labelling: Using plant system (monosaccharides and polysaccharides), animal system, chemical (Glucose 1-^{14}C) and enzymatic methods (disaccharides). Labeling of acetate (1-C^{14} and 2-C^{14}), ATP (α-P^{32} and γ-P^{32}), proteins and nucleic acids. 3 h

Applications of radioactivity: Dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity. 2 h

Biomolecules - 3 credits 45 h

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

Chemistry of monosaccharides: Pentoses, hexoses, deoxyglucose, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides.

Isolation of polysaccharides: Homopolysaccharides and heteropolysaccharides, starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate, chitin, xylans, bacterial cell wall polysaccharides, blood group polysaccharides. 6 h

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

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

Pectin and pectic polysaccharides. 4 h

Aminoacids: Nomenclature, classification and buffering properties of amino acids, 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; Khorana's solution phase synthesis, Merrifield's solid phase synthesis. 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. 8 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, peptide bond, glycosidic bond, phospodiester bond, and allolysine. 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, phosopholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG, ceramide and PAF. 4 h

Nucleic Acids: Isolation of DNA and RNA from biological sources (microbes, plants and animals). Purification of nucleic acids, 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, steam loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger leucinc zipper, helix-turn-helix, other motifs, DNA bending and kinks. 6 h

Experiments on biomolecules and seminars-- 6 credits , 12 h/week

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 lipid

Purification of polysaccharides

Colourimetric and titrimetric estimation of sugars

Assay of amino acids and nucleotides.

Organic preparations

Phytochemical assays; qualitative assays for phytochemicals, column chromatography of phytochemicals

Separation of amino acids by ascending, descending, circular and 2D-papcr chromatography. Paper chromatography of carbohydrates.

Gel filtration, ion exchange and affinity chromatography.

Electrophoresis; separation of proteins by native and SDS-PAGE,

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

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

CD of Protein, HPLC, fluorescence excitation and emission maxima, UV-vis sectra of protein, Scintillation counting,

Sample preparation for GC. Interpretation of GC and MS data

Soft core papers

Physico-chemical aspects of biology - 4 Credits 60 h

Bonding: Covalent bond, coordinate bond, coordinate bond formation in transition metals. Crystal field theory, ligand field theory, valence bond theory. Structure, bonding and special properties of water. Bonding of iron in hemologibin and cytochromes, cobalt in Vit B_{12}, magnesium in chlorophyll. Chelates; types of ligands and complexes. 8 h

Electrolytes and Non-Electrolytes: Osmotic pressure, reflection coefficient, vapour pressure, vapour pressure osmometer, Donnan membrane equilibrium. 4 h

Electrodes: Hydrogen electrode, oxygen electrode, electrode potential, oxidation and reduction, and redox potential. 4 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 glucose; anomer, epimer, sterioisomer, D and L, + and -, R and S and stereochemistry of amino acids. 10 h

Mechanism of organic reactions: Intermediates and rearrangements in organic reaction. Reaction energetics. 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. 10 h

Heterocyclic Compounds: Chemistry and biological occurance of furan, indole, thiazole, pterine, pteridine, isoalloxazine, pyrrole. Chemistry of porphyrins and heme. 4h

Secondary metabolites: Phytochemicals; terpenes, polyphenols, procyanidins, flavonoids, xanthones, alkaloids and pigments.

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. 4 h

Physiology and nutrition - 4 credits 60 h

Physiology: Basic body plan in humans, location of organs. 2 h

Blood: Composition, cells, plasma proteins and lipoproteins. Erythrocytes; structure and function. WBC; types, differential count, 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. CSF; composition and function. 8 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. Mechanesim 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. 8 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. 8 h

Minerals: Macro and micro nutrients, sources, requirements, functions and deficiency symptoms. Water metabolism; distribution in body, function, water balances, 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, 6 h

Concepts in biometry and communication - 2 credits 30 h

Biochemical calculations: Acids and bases, buffers, pH, pKa, Henderson-Hasselbach equation, buffer capacity, buffering capacity of amino acids.

Specific gravity, percent solution, dilution and dilution factors, ionic strength; molarity, normality, mole concept, Avogadro principles. 4 h

Logarithms, natural logarithms, applications in logarithmic growth. Optical density, use of log-log and semi-log paper.

Exponentials; exponential growth, non linear relationships. 4 h

Concepts of differentiation, integration and their applications in biology. Determination of maxima and minima, rate of reactions and other applications. LD_{50}, ED_{50}, IC_{50} methods of their determination. Radioactive decay; decay constant and half-life. 6 h

Science communication: Familiarizing with a glossary of terms related to sciences. Principles involved/guidelines for concentrated reading. Analytical and critical reasoning. Language components; verbal patterns. Listening comprehension.

The art of speaking: Principles and guidelines for communicating effectively. 8 h

The art of writing: Basic principles, creative writing skills. The organization of content: structure and flow of ideas, cohesive devices in written texts of various types; laboratory records, journal articles, textbooks and research reports;

Oral Presentation: Preparation of power point slides, flow of ideas, continuity of thought, simplicity of presentation material, animation effects, graphic representation, use of cartoon diagrams. Microsoft Excel; processing of data and presentation using appropriate diagrams. Bar diagrams, line graphs, scatter diagrams, 3D plots and use of standard deviation and error bars. 8 h

Essentials of Microbiology --2 Credits 30h

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

General characteristics: morphology, nomenclature and classification of bacteria, yeast molds, fungi actinomycetes, rickettesiae. 4h

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. 4h

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. 4h

Microbial Physiology: Growth, yield and characteristics, strategies of cell division, stress response. 2h

Methods of Control of Microorganisms - Bacteriostatic and bacteriocidal agents. Mechanisms of disinfection and sterilization. Physical and chemical methods. 4h

Virology - Discovery of viruses, assay of viruses. Classification of viruses based on genetic material, structure of typical viruses - Bacteriophage T4, A,, TMV, HIV. Bacteriophages as antibiotics. 4h

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells. 8h

II Semester

Hard core papers

Enzymology - 3 credits 45 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, 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, asymptote, 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. Primary and secondary plots. 2 h

Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure, isolation of ES complex, affinity labeling, chemical modification studies and active site structure investigation. 4 h

Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucleophilic and electrophoilic catalysis, intramolecular catalyses, entropy effects. Effect of temperature and pH on enzyme catalysed reaction. 4 h

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

Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC). 2 h

Metabolic regulation of enzyme activity: Feed back regulation, fine control of enzyme activity.
Fast reactions - Stopped flow, temperature jump method with examples of enzymes. 4 h

Carbohydrate and lipid metabolism – 3 credits 45 h

Introduction - Catabolism, anabolism, catabolic, anabolic 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 interconversion of hexoses. Utilization of non glucose sugars. 10 h

Biosynthesis of sucrose, starch and glycogen.

Hormonal regulation of glucose metabolism: Effect of insulin and glucogon, catecholamines,

growth hormones and carticosteroids on carbohydrate and lipid metabolism in different tissues. Action of thyroid hormones and their mechanisms.

Metabolic disorders: Disorders of carbohydrate metabolism;

diabetes mellitus, classification. 8 h

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. Regulation, α 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 (scheme only). 10h
Cholesterol synthesis and degradation and regulations: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL. Oxidized lipids and their metabolism, Foam cell formation. Regulation of blood cholesterol, triglycerides, LDL and HDL. Obesity, and mechanisms, exercise and regulation of energy metabolism. 6 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. 6h

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

Thermodynamics: 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

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, uncouphers 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. 6 h

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

Protein and nucleic acid metabolism - 3 credits 45 h

Proteins: General mechanisms of degradation in cells; ubiquitin-proteosome pathway, lysosomal pathway. Degradation and biosynthesis of glycoproteins and proteoglycans. Biosynthesis and degradation of heme and porphryns.

Non ribosomal peptide synthesis: glutathione, gramicidine.

Biosynthesis of creatin, polyamines. 8 h

General mechanisms of amino acid metabolism and regulations: Deamination, transamination, decarboxylation desulphuration, degradation and biosynthesis of individual ammo acids. Differences in the pathways in microorganisms, plants and animals. Ketogenic and glucogenic amino acids. 14 h

Regulation of amino acid biosynthesis; transglutaminase cycle, urea cycle. In born errors of amino acid degradation; Phenyl Ketonuria, alkaptonuria, maple syrup urine. 4 h

Purines and pyrimidines: Pathways of degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations. Gout and Lysch-Nyhan syndrome. Conversion of nucleotides to deoxynuclotides. Mchanisms of action of methotrexate, 5-fluorouridine, azathymidine. 14 h

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

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.

8 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. 6 h

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

5 h

Experimental methods and presentation in metabolism and enzymology - 6 credits 2 h tutorial and 12 h practical/Week

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

Estimation of iron, calcium, phosphorus,

Estimation of lactic acid, ethanol and other metabolites.

Enzymes: Acid phosphatase from plant latex and potato; specific activity, pH

and temperature optimum, energy of activation, Km and Vmax.

Esterase from pea, proteases

Amylase from sweet potato**;** purification by ammonium sulphate fractionation and enzyme characterization.

Assay methods and characterization of invertase from plant latex, protease from papaya, 5' nuceotidase, acetylcholine esterase, amino transferase, alkaline phosphatase from milk, salivary amylase. Bisubstrate reaction kinetics; glucose-6-phosphatase, LDH,

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 hard core/soft core subjects assigned. 30 h of tutorials

Soft core papers

Plant Biochemistry and bioenergetics – 4 credits 60 h

Thermodynamics: 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. 2 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. 8 h

Respiration: Plant mitochondrial electron transport and ATP synthesis. 2 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. 6 h

Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and

mechanisms of action of auxines, gibberlines, 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 cells, across membranes, through

xylem and phloem. Transpiration, mechanisms of loading and unloading of photoassimilates.

Methods in 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. 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

2 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. 4 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, uncouphers 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. 6 h

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

Clinical biochemistry– 4 Credits 60 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.4h

Blood: Composition, cells, functions of plasma proteins and lipo-proteins in diseases. Disorders of hemoglobin; thalassemia, sickle cell anemia. Anemias; microcytic, normocytic and macrocytic. 4h

Diagnostic enzymology: Mechanesims of elevated enzyme activities. Clinically important enzymes; alkaline phosphatase, creatine kinase, LDH, AST, ALT and isoezyme changes. 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. Bile pigments; formation of bilirubin, urobilinogen, bile acids. Jaundice; prephapatic, hepatic and post hepatic. Diagnosis of liver function tests, diseases of

the liver - hepatitis cholestasis, cirshosis, fatty liver and gallstones.

4 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, diarrhoea. 2h

Metabolic disorders of 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. 8 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.

4 h

Research Review 2 Credits

Students will be assigned/they will select a recent topic onwhich they will wrirte a review and submit in the form of a booklet(Similar to Dissertation) This will be evaluated based on the book and an oral presentation.

III Semester

Hard core papers

Membrane biology - 3 credits 45 h

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. 9 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. 12 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. 4 h

Muscle contraction: Mechanisms, role of calcium, calmodulin, phospholamban. 3 h

Molecular biology - 3 credits 45 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-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). 9 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. 8 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. 8 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. 8 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. 8 h

Experimental methods and presentation in molecular cell biology

- 6 credits 2 h tutorial and 12 h practical/Week

Estimation of pyruvate, urea, uric acid, ascorbic acid, creatinine, HDL-C, total cholesterol in and serum.

Lipoprotein electrophoresis.

Raising antibodies in rat. Preparation of antigen adjuvant mixture, injection, antibody titer.

Purification of antibody from egg.

Immunodiffusion, immuno electrophoresis

Restriction digestion of DNA

Cell count, viability,

Respiratory burst oxidase assay, phagocytosis assay

Micronucleus test, Onion root tip mitosis and inhibition of mitosis by mitotic inhibitors.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic from the hard core/soft core subjects assigned. 30 h of tutorials

Soft core papers

Genomics, and Gene Regulation - 4 credits 60 h

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

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. 10 h

Nucleotide sequence analysis, tools and methods, single nucleotide polymorphism. 4 h

Structure of prokaryotic and eukaryotic genes: Promoters, introns, exons, enhancers, silencers, function of introns. 2 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. 6 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. 8 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. 8 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. 4H

DNA binding protein motifs: Zinc finger, leucine zipper, helix-turn-helix and other motifs. **Regulation at the level of post translational modification:** proteins stability, N-end rule, PEST and other sequences, unbiquitin mediated degradation. 4 h

Cells, proteins and proteomics - 3 credits 45 h

Cell structure: Diversity of cell shape and size, cell theory, types of cells, ECM, cytoskeletal elements. Cell motility**,** cell-cell interaction, adhesion cell-matrix interaction. Integrins and selectins and their interaction. Inside out signaling in endothelial cells, targeting of proteins, protein sorting, polarized cells.

Structural organization and function of intracellular organelles: Cell wall, cell membrane, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast. 4 h

Neuronal physiology: Structure of neuron, axon, dendrites, synapse and neuromuscular junction. Central nervous system and peripheral nervous system α and β adrenergic neurons,

Biochemistry of vision, colour vision, taste, olfactory and auditory responses.
New models for biochemical studies: Drosophila, zebra fish, trypanosoma, and *C. elegans*. 4h

Cell division, cell cycle and regulation: Mitosis and meiosis, phases of cell cycle. Cell necrosis and programmed cell death. 4 h

Techniques in cell biology: Visualization of cells and sub cellular components by light microscopy, microscopy of living cells, resolving powers of different microscopes, scanning and transmission microscopes. Different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy, confocal microscopy and atomic force microscopy. 6 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. 4 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. 4 h

Protein and secondary structure prediction: Secondary structure prediction, secondary structure prediction methods, softwares for secondary structure prediction, protein families and classification, prediction of transmembrane regions. CATH and SCOP. 4 h

Protein modeling: Introduction, methods of protein modeling, homology or comparative modeling, model refinement, evaluation of the model. 4 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 4 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. 7h

Hormones and cell signaling - 4 credits 60 h

Endocrine System: Endocrine organs in man. Location and inter relationship of endocrine glands in man; chemistry of hormones produced by hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenals, gonads and intestine. 8 h

Functions and abnormalities: hypo and hyper production of hormones secreted by; pituitary, thyroid, pancreas, adrenals and gonads. 4 h

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

Pituitary-anatomy and structure: Hormones of anterior, posterior and median lobes. Pro-opiomelanocortin.

Testes and ovaries: hormones produced by testes and ovaries, menstrual cycle. 8 h

Regulation of hormone production and release: hypothalamus-pituitary-target organ axis and regulation by feed back mechanism. Conversion of cholesterol to steroid hormone. 4 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. 10 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.

Isolation and characterization of insulin receptor. 8 h

Mechanism of action of steroid hormones: Steroid receptors, isolation and characterization of steroid receptors. Receptor down regulation, desensitization and up regulation. 6 h

Pineal gland, melotonin and circadian rhythm. 2 h

Chemistry and action of prostaglandins, prostacyclins and thromoxanes. 2 h

Insect hormones: Structure and function of moulting hormone, ecdysone, juvenile hormones, **Pheromones:** Mechanism of perception and action. Use of pheromones in control of agricultural pests. 4 h

Chemical communication in insects: Pheromones and insect behavior. Distance and direction, communication in honey bees, chemical communication in ants. 4 h

80433 Clinical research methods: --- 2 Credits 30 hrs

Use of literature and literature sources. Design of experiments, factorial experiments, randomization, interaction among factors. Types of studies: Cohort studies, double blind, placebo control, cross over and double dummy. Overview of some studies (UKPDS, CUPS, Framingham). Clinical studies, toxicity studies, good laboratory practices, safe disposal of used and rejected samples and materials. 12 h

Discovering a drug: Proof of concept, target identification and validation, identifying the lead compound, optimization of lead compound, mechanism of action, drug target, validation of target, safety pharmacology, pharmaco-kinetics and pharmaco-dynamics, acute and chronic toxicity, CNS toxicity, hERG assay, in vitro and in vivo mechanism of action, DNA microarray and mechanism of action. 8h

Introduction to Good Clinical Practices, Clinical Trial Development: Protocol Design and Development; Case Report Form Design and Development; Principals of Data Management; Clinical Trial

Management: Maintaining and Managing Essential Documents; Recording and Reporting Non-Serious and Serious Adverse Events. 4 h

Clinical trials: Phases of clinical trial, preclinical research, investigational new drug (IND) filing.

The clinical research and new drug application approval process: The biologics research development and licensing process; product development and marketing. 6 h

IV Semester

Hard core papers

Immunology - 3 credits 45 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, T, B and accessory cells. Development of T and B cells. Sub sets of T and B cells. T-helper cells, T-killer cells, T-suppressor cells. T and B cell receptors, antigen processing and presentation. T and B 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. 11H

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). 3 h

Transplantation: Autograft, isograft, allograft and xenograft. Graft rejection, graft vs. host reaction. 2 h

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

Disorders of immunity: Immunological tolerance, auto immune disorders, AIDS, SCID. 2 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. 4 h

Defense system in plants: Host parasite interaction and defense system in plants. 2 h

Genetic engineering and biotechnology - 3 credits 45 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 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.

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

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

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

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: Fermenter; stirred fermenter, microcarrier, 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 eg skin 8 h

Endophytes and their applications. Breeding in plants and animals. Marker assisted selection. Bioremediation. 2 h

Techniques in Molecular biology – 3 credits 6 h/week

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.

Project work and research paper presentation - 4 credits 6 h/week

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 papers

Genetics and evolution - 4 credits 60 h

Basic Principles of Mendelism: Laws of inheritance, dominance, codominance, epistasis, (coomb shape in chickens) pleiotropism. Cytoplasmic inheritances (male sterility in plants, shell coiling). 4H

Gene linkage and chromosome: Linkage and recombination of genes in a chromosome. Crossing over gene mapping with three point test cross, mapping by tetrad analysis. X-linked inheritance. Polygenic inheritance, mitochondrial inheritance, Y-chromosome inheritance. Map unit. 4h

Organisation of genes in prokaryotic and eukaryotic Chromosome: Genome size and evolutionary compplexcity, C-value paradox, structure of bacterial chromosome, structure of eukaryotic chromosome, nucleosome organization, arrangement of chromatin fibers in a chromsome. Polytene chromosomes, Centromere and telomere structure. Allocating genes to chromosomes . 4h

Organization of genes in chromosomes: Single copy gene, gene families, tandemly repeating genes, pseudo genes.

Chromosome number: Ploidy, Karyotyping, sex chromosome and dosage compensation. Mobile genetic elements. 4 h

Population genetics: Populations, gene pool, gene frequency; Hardy-Weinberg law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive

radiation and modifications; isolating mechanisms; speciation; allopatry and sympatry; convergent evolution; sexual selection; co-evolution of predator-prey, pollinating insects and flowering plants. 4 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. 8h

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

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection. Mendelism; spontaneity of mutations; the evolutionary synthesis. Basis for Darwin's theory; confounding observations from embryology, comparative anatomy and biochemistry, Haeckel's drawings of embryos to fit the theory of evolution. 6 h

Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. 4 h

Paleontology and evolutionary history: Big bang theory, Age of stars, confounding data from the Hubbel space telescope, expanding universe, The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals; Punctuated equilibrium and phylectic gradualism, stages in primate evolution including Homo. Geological time scale, pre biotic conditions. Dating of fossils, different methods, current controversies concerning theory of evolution. Controversies concerning evolution of prokaryotes vs. eukaryotes, birds vs. dinosaurs, age of humans, asexual vs. sexual reproduction, cold blooded vs. warm blooded; living fossils, evolution of birds and dinosaurs, hoaxes and falsification of data (Javaman). 10 h

Molecular Evolution: Concept of Neutral theory of evolution. Molecular divergence and molecular clock**s,** molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence .6h

Biostatistics and research methodology -3 credits 45 h

Introduction to Biostatistics: Population, sample, sampling techniques, random sample, 1hr

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. 6h

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. 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 10 h

X2 test: goodness of fit, test of independence.

Non parametric statistics, sign test, rank sum test, rank correlation. 6 h

Introduction: Scope and significance of research methodology, types of research, Academic, Industrial, clinical, social sciences. Basic research, applied research,

Review of literature, identifying the gaps and formulating the hypothesis. Selecting research topics. 4 h

Research material: Use of literature and literature sources. Design of experimen ts,Factorial experiments, randomization, interaction among factors, Choosing sample size, alpha and beta errors.4 h

Toxicity studies, Good Laboratory practices, Handling of Rodents and non rodents in laboratory experiments,Safe disposal of used and rejected samples and materials.
8h .

Behavioral biology and ecology - 4 credits 60 h

Introduction: Classification of behavior types, reflexes and complex behavior, development of behavior and phylogeny of behavior. 2 h

Genetics and behavior: Micro evolutionary changes in behavior; Hamilton's rule, inclusive fitness, kin selection, altruism and altruistic behavior. Imprinting: Work of Timberger and Lorenz. 8 h

Reproductive behavior: Sexual selection, competition, dominance and aggression; alternate mating strategies, female choice, runway selection, mating system, monogamy, polygamy, polyandry. 10 h

Social behavior: Thwarting and conflict behavior, pure attack and escape, threat displays, social signals, appeasement displays, displacement activities, territorial and courtship conflicts, Mimicry Batsean and Mullerian. 8 h

The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. 6 h

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation; demes and dispersal, interdemic extinctions, age structured populations. 6 h

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. 4 h

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. 4 h

Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). 6 h

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Applied ecology: Environmental pollution; global environmental change. 6 h

Open Elective for II Semester

Lipids and health - 4 credits 64 H

Introduction to Fats: Fats and their classification, Fatty acids, essential fatty acids, triglycerides, cholesterol, trans fats and saturated fats, unsaturated fats-mufa, pufa. Ceramide, ω3 and ω6 fatty acids, DHA. 10 h

Functions of fats: Nutritional role, other functions like hormones, taste, cushioning,

Storage and distribution of fats in the body; visceral fat, subcutaneous fat, BMI. 6 h

Visible and invisible fat sources of fats, fried foods, fatty acid composition of oils, non saponifiable fraction and their beneficial effects; sesamol, oryzanol, hydroxy fatty acids, ricinoleic acid. Toxic components in oils. 8 h

Which oil is good? Why vegetable oil? Is butter good or bad? Margarine fish oil, fat substitutes (olestra). 6 h

Cholesterol; function of cholesterol, steroidogenesis, vit D3, fat soluble vitamins.

Storage and transport of cholesterol.

LDL, HDL ,VLDL, Lp(a) atherosclerosis risk factors. 8 h

Obesity, anti obesity

Obesity and diabetes

Diets and exercise 6 h

Fad diets, wellness diets and fitness diets, myths about fats. 6 h

Calculations and demonstrations in:

Determination of body fats- w/h ratio, visceral fat, BMI

Tests for fat adulteration

Solidification temp of coconut oil,

TLC of Fried oils

Detection of animal fat in vegetable oils

Extraction of oils by soxhlet apparatus (demonstration). 14 h

Open Elective for III Semester

Venom pharmacology – 4 credits 64 h

Introduction: Types of toxins – microbial, plant and animal origin. 6 h

Venomous organisms – snakes, spiders, scorpions, sea shells, fishes and toads. Ecosystems; distribution, adaptations. 6 h

Snakes - Indian snakes – fear, traditional and mythological beliefs – venomous and non-venomous snakes, classification; venom gland, venom functions, local and scientific nomenclature and distribution of snakes. 10 h

Venom composition: Organic and inorganic – enzymes and toxins; neurotoxins, cadiotoxins, myotoxins, hemotoxins, coagulants and non enzymatic toxins. 8 h

Venom toxicity: Agents responsible for local toxicity (edema, hemorrhage, myonecrosis) and systemic toxicity (effects on nervous, circulatory, respiratory, hemostatic). Animal models; mice, rats, rabbits, horse, goat and camel. 10 h

Antidote: First aid, antivenom (monovalant and polyvalent) preparations, folk medicines (plant extracts, animal extracts and isolates), drawbacks of antivenom and folk medicine. 10 h

Applications of Toxins: Drug discovery (prototypes), anticoagulant, procoagulant, neurotoxins, analgesic, opiates and enzymes as tools in biology. 8 h

Socioeconomic problems: Epidemiological studies, occupational hazards, cost effect, health complications. Ethical issues; conservations, CPCSA guidelines, Wild life act. 4 h

Clinical Diagnostis in health and diseases - 4 credits 64 h

Introduction: General health, syndrome and common diseases – communicable and non-communicable diseases. 6 h

Samples for analysis: Blood, urine, pleural fluid, synovial fluid, cerebro spinal fluid and tissues and histology. 4 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. 4 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. 2 h

Test for Brain function: EEG, MRI, CT. 4 h

Test for Surgery: Bleeding time, clotting time. 2 h

Infection: Bacterial, viral, fungal and protozoans. 4 h

Blood: Total cell count, differential count, erythrocyte sedimentation rate. 2 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. 6 h

Non communicable diseases:

Diabetes: Blood sugar, urine sugar, glucose tolerance test, HbA1c. 4 h

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

Special test: X-ray, CT, MRI, Doppler, TMT, angioplasty. 4 h

Cancer markers: ELISA. 2 h

Professional hazard: High risk groups (farmers, heavy duty machine workers, CEOs, athlets).

4 h

Doping in sports: 4 h

Drug addition: 4 h