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

The Choice Based Credit System (CBCS) comprises Hard Core, Soft Core subjects for Molecular Biology Students and Open Elective for students other than Molecular Biology. Following shall be the Minimum and maximum subjects per semester.
The credit pattern is Lecture : Tutorial : Practical (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 Department
- 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 with life science subjects are eligible. Students from professional degrees such as Pharmacy, Dental, Agricultural, Medicinal, Veterinary, Engineering with Life Science are also 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		Fundamentals of Chemistry	HC	3	0	0	3
2		Separation Techniques	HC	3	0	0	3
3		Analytical Techniques	HC	3	0	0	3
4		Practical-1: Techniques, and seminar	HC	0	2	4	6
5		Essentials of Biomolecules	SC	3	0	0	3
6		Basics of Microbiology	SC	3	0	0	3
7		Animal Physiology	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		Basics of Enzymology	HC	3	0	0	3
2		Introduction to Molecular Biology	HC	3	0	0	3
3		Practical- 2: Restriction enzyme assays, seminar and Dissertation.	HC	0	2	4	6
4		Carbohydrate and Lipid metabolism, and Bioenergetics	SC	3	0	0	3
5		Protein and Nucleic acid metabolism	SC	3	0	0	3
6		Plant Physiology	SC	3	0	0	3
7		Genetic Engineering – Pros & Cons	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		Advanced Molecular Biology	HC	3	0	0	3
2		Cell structure and function	HC	3	0	0	3
3		Practical-3: Immunological and cloning techniques and seminar	HC	0	2	4	6
4		Molecular Immunology	SC	3	0	0	3
5		Omics and Bioinformatics	SC	3	0	0	3
6		Microbial Technology and Bioprocessing	SC	2	0	0	2
7			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		Recombinant Technology	HC	3	0	0	3
2		Molecular Genetics	HC	3	0	0	3
3		Practical-4: Project Work	HC	0	0	6	6
4		Plant Biotechnology	SC	3	0	0	3
5		Animal Biotechnology	SC	3	0	0	3
6		Molecular basis of Evolution	SC	3	0	0	3
7		Basics of Biostatistics	SC	2	0	0	2
8		Genetic Engineering – Pros & Cons	OE	3	1	0	4

I Semester Biochemistry

Hard Core

Fundamentals of Chemistry - 3 Credits 48 h

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

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

Stereochemistry: Importance of stereochemistry, position and order of groups around carbon. Geometric and optical isomerism; absolute and relative configuration. Symmetry view of chirality, relation between chirality and optical activity, representation of chiral structures by Fischer. Structure and stereochemistry of sugars and amino acids; anomer, epimer, diastereomer, sterioisomer, D and L, (+) and (-), R and S. 12 h

Mechanism of organic reactions: Intermediates and rearrangements in organic reaction. Reaction energetic. Classification of rearrangement reactions. Reaction rates, order and molecularity of reaction. Mechanisms and stereochemistry of substitution (electrophilic and nucleophilic - sN^1 and sN^2 reactions) addition, elimination and rearrangement reactions. Mechanisms of ester hydrolysis. Property of aromaticity and resonance. 12 h

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

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

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

PCR, RT-PCR, Microarray. 2 h

Analytical 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}H, ^{14}C, ^{32}P, ^{131}I, ^{35}S, concept of half-life, decay constant, detection and quantitation - GM counter and solid and liquid scintillation counter. Specific activity, autoradiography and their applications. 8 h

Applications of radioactivity: Labeling of proteins and nucleic acids, Dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity. 4 h

Practical - 1: Techniques and seminar 6 credits

12 h/week (Practical and Tutorials)

Preparation of buffer. Media preparation; nutrient broth, nutrient agar, potato dextrose agar, Czapekdox agar, Mac Conkey's agar.

Sterilization techniques, hot air oven, autoclave/pressure cooker, filtration unit.

Study of pure culture techniques: Serial dilution, pour plate, spread plate, streak plate, point inoculation.

Measurement of growth using -Turbidometer/ photocolorimeter/ spectrometer and Haemocytometer (Yeast cells)

Staining: Simple staining and negative staining, Differential (Gram's staining).

Observation of bacterial motility by hanging drop method.

Effect of disinfectants, antiseptics and antibiotics on the growth of microorganisms.

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

Isolation of plasmid DNA Extraction of DNA and RNA from, Drosophila, coconut endosperm. Criteria of purity – 260/280 UV absorption ratio.

Colorimetry**;** applications of Beer-Lambert's law, determination of extinction coefficient. Colorimetric estimation of Nucleic aicd and proteins. Estimation of protein by Biuret and Lowry's methods.

UV absorption of protein and Nucleic acid. Hypo and hyper-chromicity of Nucleic acid on heat denaturation.

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

Essentials of 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; agreecan, syndecan, and decorin. Pectin and pectic polysaccharides. 6 h

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

Peptide bond: Features of the peptide bond, naturally occurring peptides; glutathione, enkaphalins and endorphins. Chemical synthesis of peptides; solution phase synthesis, Merrifield's solid phase synthesis, and peptide ligation. 6 h

Determination of amino acid compositions: Acid and base catalyzed hydrolysis, separation, quantification, determination of N and C terminal residues, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl).

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

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

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

Lipids: Classification of lipids; oils, fats, and waxes. Occurrence and properties of fatty acids, esters of fatty acids, cholesterol, phospholipids, glycolipids, sphingolipids, cerebrosides and gangliosides. 4 h

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

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

Basics of Microbiology - 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. Recent developments in Microbiology. Branches of Microbiology. 6 h

General characteristics: morphology, nomenclature and classification of bacteria, yeast, molds, fungi, actinomycetes, rickettesiae and protozoa. 4 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. Microscopy; simple, compound, phase contrast, fluorescent and electron microscopy. 6 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. 4 h

Microbial Physiology: Growth, yield and characteristics, strategies of cell division, stress response. 4 h

Strain improvement methods: recombination using mutagens, protoplast fusion, r-DNA technology, selection of improved strains: Enrichment technique. 6 h

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

Virology - Discovery of viruses, assay of viruses. Classification of viruses based on genetic material, structure of typical viruses - Bacteriophage T4, TMV, HIV. Bacteriophages as antibiotics. 6 h

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. 8 h

Animal Physiology - 3 Credits 48 h

Introduction: Meaning and scope of animal physiology. Definition of cell types, tissue, organs and systems. 2 h

Circulatory system: 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. 6 h

Nervous system: Structure of a neuron, nerve transmission, CSF; composition and function. 4 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

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

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Mechanism of HCI production in the stomach. Gastrointestinal hormones and role of pancreas in digestion. Basal metabolic rate (BMR), factors affecting BMR, specific dynamic action of foods. 4 h

Nutrition: Concepts of macro and micro nutrients, essential nutrients and their classification. Vitamins and minerals. 8 h

Thermoregulation : Effect of Temperature on biological system. Temperature relations of Poikilotherms and homeotherms, acclimation and acclimatization to cold and heat. Neuronal basis of thermoregulation. 4 h

Physiology of reproduction: Hormonal control of testicular and ovarian functions. estrous and menstrual cycle, implantation, gestation and partiurition. Modern trends in reproduction – Invitro fertilization, cloning, sperm bank, artificial insemination, test tube baby. 6 h

Adaptation : Adaptation to extreme environment - Desert, high altitude and salt tolerance. 2 h

II Semester Biochemistry

Hard Core

Basics of 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. Vmax, Km and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden. Scatchard plot. 5 h

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

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

Determination of Ki and Kd. 2 h

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

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

Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure. Isolation of ES complex, affinity labeling, chemical modification studies, site directed mutagenesis. 4 h

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

Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay net work. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes, coenzymic action of NAD^+, FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid. 7 h

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

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

Introduction to 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-antiparellel nature: Nearest neighbour base frequency analysis. Replication of DNA, semi conservative nature; Messelson and Stahl experiment. Replication of double stranded DNA, direction of replication, discontinuous replication, Okazaki fragements. DNA polymerase I II and III, DNA ligase, DNA topoisomerases. Fidelity of replication, replication in viruses, rolling circle model, single stranded DNA virus. Applications of mitochondrial DNA. Trombon model, translesion synthesis (DNA pol IV and V). 10 h

Transcription: Colinerity of genes and proteins, RNA polymerase I, II and III. RNA biosyntehsis in prokaryotes and eukaryotes; initiation, elongation and termination. RNA dependent RNA synthesis, RNA replicase of Qβ virus. Processing of eukaryotic RNA, cap addition, poly A tail addition, RNA editing. Processing of tRNA and mRNA transcripts. 10 h

Translation: Genetic code, triplet codon, universality features of the genetic code, assignment of codons, studies of Khorana, Nirenberg, triplet binding techniques, degeneracy, wobble hypothesis, evolution of genetic code and codon usage, variation in the codon usage. 10 h

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

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

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

Practical - 2: Enzyme assays and restriction digestion, seminar and Dissertation. 6 Credits

12 h/week (Practical and Tutorials)

Enzymes: Salivary Amylase, and Esterase from Pea extract.

Specific activity, pH and temperature optimum, energy of activation, Km and Vmax.

Photo-oxidation of methylene blue. Photosynthetic reduction of
2,6 dichlorophenolindophenols.

Preparation of E.coli Competent cells using magnesium chloride method, Transformation of plasmid DNA in E.coli and yeast.

Restriction digestion of plasmid DNA, Electrophoresis of DNA and RNA.

Transformation, identification by antibiotic resistance and chromogenic substrate.

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 and lipid metabolism, and Bioenergetics - 3 Credits 48 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. 6 h

HMP shunt pathway, interconversion of hexoses. Utilization of non glucose sugars. Biosynthesis of sucrose, starch and glycogen. 4 h

Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; Fatty acid degradation; β-oxidation Knoop's experiment, saturated and unsaturated fatty acids. 4 h

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. 4 h

Cholesterol synthesis and degradation and regulations: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL. 2 h

Phospholipid biosynthesis and regulations: Denovo pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Biosynthesis of prostaglandins, thromboxanes leukotrienes. 4 h

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. 2 h

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. 8 h

ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. 5 h

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

Protein and nucleic acid 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

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

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

Differences in the pathways in microorganisms, plants and animals. 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

Purines and pyrimidines: Pathways of degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations. 8 h

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

Biosynthesis of cofactors: NAD^+, FAD and coenzyme A, polyamine biosynthesis and their metabolic role. 2 h

Plant Physiology - 3 Credits 48 h

Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. 4 h

Electron flow and photophosphorylation; 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 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, 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. 6 h

Solute transport and photo assimilate translocation: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil through xylem and phloem. Transpiration, mechanisms of loading and unloading of photoassimilates. 6 h

Phytochemicals: Extraction, fractionation and characterization. 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 and defense system in plants. 4 h

Open Elective (II and IV Semesters; Even)

Genetic Engineering - Pros & Cons - 4 Credits (3L + 1T) 48 h

Cell structure and subcellular organells and their function. Origin of mitochondria and chloroplast. Prokaryotes and eukaryotes. 6 h

DNA and RNA as Genetic materials. Central Dogma of Molecular Biology. 4 h

Work of Watson and Crick, Rosalind Franklin, Chargaff, Hershey and Chase, Stahl and Messelson, Kornberg, Khorana, Barbara Metchinkof. 6 h

Gene-polypeptide concept. Cistron, mono, poly. Genes and gene families.
Coding and Non coding DNA, jumping genes. 6 h

Human genome project and its reality. Gene libraries of important organisms. 4 h

Chromosomal basis of Genetic disorders. Sickel cell anemia, Thalasemea, 4 h

Cancer at genetic level – acquired and inherited. 2 h

Genetically modified foods. Golden rice, BT Cotton and Brinjal, 6 h

Development of resistant variety crops, Seed less fruits, Hybrid variety fruits and vegetables. 6 h

Pharmaceutical Applications: Production of Insulin, Antibodies, vaccines. 4 h

III Semester Biochemistry

Hard Core

Advanced Molecular Biology - 3 Credits 48 h

Gene structure: Structural organization of prokaryotic and Eukaryotic gene. Complexity of gene. 2 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. 6 h

Regulation at the level of RNA processing: RNA export and RNA stability, factors affecting RNA stability and RNA degradation. 6 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. 8 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. 4 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, unbiquitin mediated degradation. 6 h

Cell structure and function - 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. 6 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. 4 h

Functions and abnormalities: Hypo and hyper production of hormones secreted by; pituitary, thyroid, pancreas, adrenals and gonads. 2 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. Conversion of cholesterol to steroid hormone. 4 h

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

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. 4 h

Second messengers: $1P_3$, DAG, cAMP, protein kinases. Nitric oxide signaling; generation and action. 4 h

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

Pineal gland, melotonin and circadian rhythm. 2 h

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

Newly discovered hormones. 2 h

Insect hormones: Structure and function of moulting hormone, ecdysone, juvenile hormones, Pheromones, communication in insects.

Application of insect hormones. 4 h

Practical - 3: Experiments in Immunology and cloning techniques and seminar 6 Credits

12 h/week (Practical and Tutorials)

Isolation of IgG from egg yolk and from Serum. ELISA and Western Blot analysis of expressed proteins.

Primer Design, PCR, Reverse Transcribed PCR, Protein Electrophoresis.

RFLP, RAPD.

Cloning Strategies; Sticky and blunt end ligation, Identification of clone.

Auxotrophes. Complementation.

Protein expression in E.coli / Yeast host system.

Cloning of a gene from Yeast / Drosophila / Plant Genome.

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

Soft core

Molecular 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-lβ, IL-2, TNFα. Suppression of immune response, immunoglobulin genes, generation of immunoglobulin diversity, gene rearrangement and other mechanisms, clonal selection theory of Burnet. 10 h

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

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

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

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

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

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

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

Omics and Bioinformatics - 3 Credits 48 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). 4 h

Sequence comparison and database search: Introduction, pair wise alignment, global alignment, local alignment, multiple sequence alignment. 4 h

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. 4 h

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

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 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. 4 h

Microbial Technology and Bioprocessing Technology - 2 Credits 24 h

Industrially Important Microorganisms: Development, Growth cycle, effect of nutrients, energetic of growth, growth rate and cell cycle. 4 h

Metabolites: Primary and secondary metabolites. 2 h

Fermentors and Bioreactors: Fermentor; stirred fermentor, microcarrier, Batch culture. Bioreactors**;** control systems, operation, optimization, control and monitoring of variables such as temperature, agitation, pressure, pH, online measurements and control**,** use of biosensors in bioreactors. 6 h

Downstream processing of metabolites: Separation of cells, foam and flocculation. Disintegration of microorganisms, mechanical and enzymatic methods.

Filtration; plate filters, rotary vacuum filter, membrane filtration, ultra filtration and reverse osmosis. 4 h

Centrifugation, chromatographic techniques, absorption, spray drier, drum dryers, freeze dryers. 2 h

Microbial products: Microbial production of vitamins, enzymes, organic acids, amino acids, polysaccharides, antibiotics, ethanol, biosurfactants. 2 h

Drug development and pharmaceutical process: Production of pharmaceuticals by genetically engineered cells (hormones, interferons), microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics), new generation antibiotics, protein engineering, drug design, drug targeting Nanotechnology. 4 h

IV Semester Biochemistry

Hard Core

Recombinant Technology - 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. 4 h

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. 8 h

Vectors: Plasmids, phage, cosmids and phagemid. Yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors, construction of expression vectors. 8 h

Ligation: Blunt end and sticky end ligation, use of linkers and adopters, homo polymer tailing, colony hybridization, plaque hybridization. 4 h

Transformation: Micro injection, electroporation, lipofection, calcium phosphate method, protoplast fusion/somatic cell hybridization and biolistic methods. 4 h

Transgenic plants and animals, gene knock out. 2 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. 6 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. 4 h

Mapping in Prokaryotes and Viruses: Bacterial transformation and transduction, conjugation; F+ plasmids, Hfr cells, time of entry mapping. Arrangement of genes in phage chromosome, plaque formation and lytic cycle. Fine structure of rII locus of T4. Lysogeny and λ phage. 4 h

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

Molecular Genetics - 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). 4 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. 4 h

Chromosome number: Ploidy, Karyotyping, sex chromosome and dosage compensation. Mobile genetic elements. 6 h

Organisation of genes in prokaryotic and eukaryotic Chromosome: Genome size and evolutionary compplexcity, C-value paradox. 4 h

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. 8 h

Molecular Genetics: Mutations; nature of mutations, spontaneous and induced mutation, conditional, lethal (temperature sensitive) mutation. 4 h

Biochemical basis of mutation. Point mutation, base substitution mutation, missense, nonsense and silent mutation. Mutation rates. 4 h

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. 4 h

Chromosomal Basis of Human Diseases: Extra or missing chromosome, abnormality in chromosome structure; deletion, duplication,

inversion, translocation. 4 h

Practical - 4: Project work **6 Credits**

12 h/week (Practical and Tutorial)

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.

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.

Soft Core

Plant Biotechnology - 3 Credits 48 h

Protoplast Technology: Isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization, applications of somatic hybrids/ cybrids. 4 h

Secondary metabolite production: Induction of secondary metabolites by plant cell culture, technology of plant cell culture for production of chemicals, biotransformation using plant cell culture. Bioreactor systems and models for mass cultivation of plant cells. 6 h

Plant transformation techniques: Methods of gene transfer in plants, *Agrobacterium* mediated transfer- mechanism of DNA transfer. 4 h

General features of Ti and Ri plasmids, role of *vir* genes, design of expression vectors, use of promoters and reporter genes; viral vectors, direct gene transfer methods- electroporation, microinjection, particle bombardment, selection of transformants, screening and field trials. 6 h

Cell and Tissue Culture Technology: Role of hormones in growth and development of plants, tissue-specific hormones. Callus Induction, Organogenesis, Somatic embryogenesis, cell suspension culture and synthetic seeds. 6 h

Micropropagation: Propagation from pre-existing meristem, shoot apical meristem, shoot and node culture, micropropagation stages and applications. 4 h

Haploid Technology: Methods of haploid culture, Factors affecting anther and microspore cultures, applications. 4 h

Transgenic plants: Herbicide resistance, resistance against biotic stress- bacterial, viral, fungal and insect resistance, abiotic stress, improved crop productivity, improved nutritional quality, transgenic plants for floriculture, Qualitative trait loci and marker studies. 4 h

Molecular farming: Transgenic plants as production systems-production of alkaloids, steroids, colouring agents, flavoring agents, biodegradable plastics, industrial enzymes, therapeutic proteins, biopharmaceuticals, edible vaccines, plantibodies. 4 h

Germplasm preservation: Preservation of seed-propagated species, preservation of pollen, preservation of vegetatively propagated species, pre-treatment of plant and propagule, cryopreservation, cryoprotectant, warming rate and recovery, gene banks, applications. 6 h

Animal Biotechnology - 3 Credits 48 h

Culture of animal cells: Advantages and limitations of tissue culture, aseptic handling, and facilities required media and cell lines. 2 h

Primary culture: Isolation of mouse and chick embryos, human biopsies, methods for primary culture, nomenclature of cell lines, sub culture and propagation, immortalization of cell lines, cell line designation, selection of cell line and routine maintenance. 4 h

Cloning and Selection: Cloning protocol, stimulation of plating efficiency, suspension cloning, isolation of clones, isolation of genetic variants, interaction with substrate, selective inhibitors. 4 h

Cell separation and characterization: Density based, antibody based, magnetic and fluorescence based cell sorting. 2 h

Characterization of cells based in morphology, chromosome analysis, DNA content, RNA and protein, enzyme activity, antigenic markers, cytotoxicity assays. 4 h

Cell quantitation, cell culture contamination: monitoring and eradication, cryopreservation. 2 h

Culturing of specialized cells: Epithelial, mesenchymal, neuro ectodermal, hematopoietic gonad and tumor cells, Lympocyte preparation, culture of amniocytes, fish cells, confocal microscopy. Stem cell culture and its applications. 4 h

Organic and embryo culture: Choice of models, organ culture, histotypic culture, filter-well inserts, neuronal aggregates whole embryo culture eggs, chick and mammalian embryos. 4 h

Cell and Tissue engineering: Growth factors for *in situ* tissue regeneration, biomaterials in tissue engineering, approaches for tissue engineering of skin, bone grafts, nerve grafts. Haemoglobin-based blood substitutes, bio artificial or biohybrid organs. Limitations and possibilities of tissue engineering. 4 h

***In vitro* fertilization and Embryo transfer:** *In vitro* fertilization in Humans, Embryo transfer in Humans, Super ovulation and embryo transfer in
farm animals (Cow). 6 h

Cloning of Animals: Methods and uses. Introduction, nuclear transfer for cloning, cloning from embryonic cells, adult and fetal cells. Cloning from short-term cultured cells. Cloning from long-term cultured cells. Cloning efficiency, cloning for production of transgenic animals, gene targeting for cloned transgenic animals, cloning for conservation. 4 h

Transfection methods and transgenic animals: Gene transfer, transfection of fertilized eggs or embryos, unfertilized eggs, cultured mammalian cells, targeted gene transfer. Transgenic animals and applications. The legal and socio-economic impact of biotechnology at national and international levels. 4 h

Biosafety regulations: guidelines for research in transgenic animals, public awareness of the processes of producing transgenic organisms. 4 h

Molecular Basis of Evolution - 3 Credits 48 h

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection. 6 h

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. 8 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. 8 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 . 8 h

Evolutionary history: 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. 6 h

Geological time scale, pre biotic conditions. Dating of fossils, different methods, current controversies concerning theory of evolution. 4 h

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). 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-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. 7 h

X2 test: goodness of fit, test of independence.

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

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