School of Biotechnology

Course content of M.Sc. Molecular Medicine

SEMESTER I

Biochemistry **Credit hours: 3**

Unit I Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.

Unit II: Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit III Enzyme catalysis: General principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit IV Sugars: Mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit V Self-assembly of lipids: micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit VI Bioenergetics-basic principles: equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways, glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

Unit VII Calvin cycle and pentose phosphate pathway: glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

Recommended Textbooks and References: 1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman. 2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth. 3. Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons. 4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261. 5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Microbiology — Credit hours: 3

Unit I Microbial characteristics: Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit 2 Microbial diversity: Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid

bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit III Control of microorganisms: Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit IV Virology: Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.

Unit V Host-microbes interaction: Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Recommended Textbooks and References: 1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill. 2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill. 3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons.

Genetics — Credit hours: 3

Unit I Genetics of bacteria and bacteriophages: Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

Unit II Yeast genetics: Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

Unit III Drosophila genetics as a model of higher eukaryotes: Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

Unit IV Population genetics and genetics of evolution: Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-

breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

Unit V Quantitative genetics of complex traits (QTLs): Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

Unit VI Plant genetics: Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.

Recommended Textbooks and References: 1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett. 2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman. 3. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown. 4. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

Cell Biology — Credit hours: 3

Unit I Introduction to the cell: Evolution of the cell, From molecules to first cell, From prokaryotes to eukaryotes, Prokaryotic and eukaryotic genomes, Single cell to multicellular organisms. Membrane structure and function: Models of membrane structure, Membrane proteins, Membrane carbohydrates, Membrane transport of small molecules, Membrane transport of macromolecules and particles. Structural organization and function of intracellular organelles: The lysosomes, Ribosomes, The peroxisomes, The golgi apparatus, The endoplasmic reticulum, Mitochondria and chloroplast, Structure of mitochondria and chloroplast, Oxidation of glucose and fatty acids, Electron transport oxidative phosphorylation, Chloroplast and photosynthesis.

Unit II Protein secretion and sorting: Organelle biogenesis and protein secretion, synthesis and targeting, of mitochondria, chloroplast, peroxisomal proteins, translational modification in the ER. Intracellular traffic, vesicular traffic in the secretary pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.

Unit III The cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. Cell communication and cell signaling: Cell adhesions, Cell junctions and the extra cellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extra cellular matrix.

Unit IV Cell growth and division: Overview of the cell cycle and its control, The molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation. Cell to cell signaling, Overview of the extra cellular signaling, Identification of cell surface receptors, G-protein coupled receptors and their effectors, Second messengers, Enzyme-linked cell surface receptors, Interaction and regulation of signaling pathways.

Recommended Textbooks and References: 1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). Molecular Biology of the cell. Garland publishers, Oxford. 2. Celis, J.E. (2006). Cell biology: A laboratory handbook, Vol 1, 2. 3. Academic Press, UK. 3. Gupta, P.K. (2008). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India. 4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India

Concepts and Prospects of Molecular Medicine — Credit hours: 3

Unit I Molecular Basis of Diseases: Human genetics relevant to molecular medicine, single nucleotide polymorphisms, multiple gene polymorphisms, single and multi-gene diseases, gene-environment interactions in disease manifestation, and identification of diseases gene.

Unit II Molecular Medicine Therapeutics: Gene therapy and recombinant molecules in medicine and therapeutic development, Antiviral therapies, vehicles for gene therapies, RNAi and human diseases, alternate splicing and human disease.

Unit III Signal Transduction and its role in Human Diseases: Cellular and tissue microenvironment in diseases, drug resistance with convention chemotherapies, construction of knock-out and transgenic animals, Protein as causes of human diseases.

Unit IV Adjuvant therapies: monoclonal antibodies as drugs, nanobiotechnology and its applications in molecular medicine, Stem cell research and its application in human health

Recommended Textbooks and References: 1. Littwack, G. (2008). Human Biochemistry and Disease. Academic Press. 2. Trent, R. J. (2012). Molecular Medicine, Fourth Edition: Genomics to Personalized Healthcare. Academic Press. 3. Trent, R. J. (2005). Molecular Medicine: An Introductory Text. Academic Press. 4. Elles, R., Mountfield, R. (2011). Molecular Diagnosis of Genetic Diseases. Springer Publication. 5. Liciniio, J., Wong, M. L. (2003). Pharmacogenomics: The Search for Individualized Therapies. Wiley-VCH Verlag GmbH & Co. KGaA. 6. Audet, J.,Stanford, W.and Stanford,W. L. (2009) Stem cells in regenerative medicine. New York, Humana press

Biostatistics — Credit hours: 3

Unit I Algebra: Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.

Unit II Calculus: Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series etc.).

Unit III Mathematical models in biology: Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

Unit IV Statistics: Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Recommended Textbooks and References: 1. Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. New York, NY: Palgrave Macmillan. 2. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science. 3. Billingsley, P. (1986). Probability and Measure. New York: Wiley. 4. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press. 5. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

Fundamentals of Programming — Credit course: 2

UNIT I PYTHON BASICS ,CONDITIONAL &LOOPS: Installation of Python and Ipython Notebook, Python Objects, Number & Booleans, Strings, Container objects, Mutability of objects, Operators - Arithmetic, Bitwise, comparison and Assignment operators, Operators Precedence and associativity. Conditions (If else, if-elif-else), Loops (While, for), Break and Continue statements, Range Functions

UNIT II STRING OBJECTS AND LIST OBJECTS: String object basics, String methods, Splitting and Joining Strings, String format functions, list object basics, list methods, List as stack and Queues, List comprehensions,

UNIT III TUPLES, SET, DICTIONARIES & FUNCTIONS: Tuples, Sets, Dictionary Object basics, Dictionary Object methods, Dictionary View Objects. Functions basics, Parameter passing, Iterators, Generator functions, Lambda functions, Map, Reduce, filter functions

UNIT IV OOPS CONCEPTS & WORKING WITH FILES OOPS: basic concepts, Creating classes and Objects, Inheritance, Multiple Inheritance, Working with files, Reading and writing files, Buffered read and write, Other File methods

UNIT V MODULES, EXCEPTION HANDLING & DATABASE PROGRAMMING: Using Standard Module, Creating new modules, Exceptions Handling with Try-except, Creating, inserting and retrieving Table, Updating and deleting the data. Data Ananlysis- Numpy variable, Numpy manipulation, Scipy, Pandas intro. Descriptive analysis, Pandas Input-output, Pandas manipulation.

Recommended Textbooks and References: 1. Head First Python 2e: A Brain-Friendly Guide Paperback – Illustrated, 16 by Paul Barry, Oreilly 2. Python: The Complete Reference Paperback – 20 March 2018 by

Martin C. Brown (Author), TMH Publication 3. Let Us Python by Yashavant Kanetkar , 1 January 2019, BPB publication 4. Python Programming, A modular approach, First Edition, By Pearson Publication by Taneja Sheetal and Kumar Naveen , 26 September 2017

Fundamentals of Programming Lab — Credit hours: 2

Write a program in python :

1. To print the largest/smallest of two numbers
2. To input three numbers and print the greatest of all
3. To read two numbers x and n and print x n (first write with the use of operator and then write with the help of inbuilt function
4. To input the value of x and n and print the sum of the series: a. 1+x+x 2+x 3+x 4+……x n
5. To check if a number is a perfect number or not
6. Write a program to compute distance between two points taking input from the user (Pythagorean Theorem)
7. Write a program to count the numbers of characters in the string and store them in a dictionary data structure
8. To print factorial of a number using function
9. To print factorial of a number using recursion
10. To count no of vowels in a string that was given as input by user
11. Write a function to find all duplicates in the list.
12. Write a function unique to find all the unique elements of a list.
13. Write a program to perform addition of two square matrices
14. Write a program to perform multiplication of two square matrices
15. To read from a text file and print each word separated by # symbol, example #vipin # rai

Biochemistry and Cell Biology lab — Credit hours: 2

1. Preparation of mitotic & meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Sectioning of tissues.
5. Histochemical techniques (Fixing, Processing, Staining).
6. Preparation of Solutions, buffers, pH setting etc.
7. Amino acid and carbohydrate separations by paper & thin layer chromatography.
8. Quantitative Estimation of Proteins, Sugars, total lipids and amino acids.
9. Assay and estimation of different enzymes e.g. invertase, amylases, acid and alkaline phosphatases in plant seeds.
10. Principle and application of electrophoresis, Native, SDS PAGE. 6. Estimation of total phenolic compounds.

11. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
12. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments).

***More practicals may be added/modified from time to time depending on available facilities / faculties.**

Microbiology Lab — Credit hours: 2

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc.
5. Preparation of bacterial smear and Gram's staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures 9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples

Recommended Textbooks and References: 1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company. 2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds. 3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology

SEMESTER II

Genetic Engineering — Credit Hours: 3

Unit I Introduction and tools for genetic engineering: Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization

Unit II Different types of vectors: Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit III Different types of PCR techniques: Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit IV Gene manipulation and protein-DNA interaction: Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display

Unit V Gene silencing and genome editing technologies: Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model. Iintroduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Recommended Textbooks and References: 1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science. 5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Immunology — Credit Hours: 3

Unit I fundamental concepts and overview of the immune system: Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

Unit II Immune responses generated by B and T lymphocytes: Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

Unit III Antigen-antibody interactions: Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

Unit IV Vaccinology: Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit V Clinical immunology: Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI Immunogenetics: Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex

Recommended Textbooks and References: 1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman. 2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub. 3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science. 4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press. 5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press. 6. Parham, P. (2005). The Immune System. New York: Garland Science

Bioinformatics — Credit hours: 2

Unit I Bioinformatics basics: Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

Unit II DNA sequence analysis: DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

Unit III Multiple sequence analysis: Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Unit IV Protein modelling: Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

Unit V Protein structure prediction and virtual library: Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.

Recommended Textbooks and References: 1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press. 2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell. 5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

Genomics and Proteomics — Credit hours: 2

Unit I Basics of genomics and proteomics: Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, and mitochondria.

Unit II Genome mapping: Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques,

FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping.

Unit III Genome sequencing projects: Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit IV Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

Unit V Proteomics: Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

Unit VI Functional genomics and proteomics: Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; proteinprotein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

Recommended Textbooks and References: 1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. 2. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press. 3. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

Research Methodology and Scientific Communication Skills Credit hours: 3

Unit I History of science and science methodologies: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit II Preparation for research: Choosing a mentor, lab and research question; maintaining a lab notebook.

Unit III Process of communication: Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills -

formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit IV Scientific communication: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and nonblind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Recommended Textbooks and References: 1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press. 2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press. 3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558. 4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India. 5. Movie: Naturally Obsessed, The Making of a Scientist.

Molecular Biology — Credit hours: 3

Unit I Structure, Conformation, Denaturation and Renaturation of Nucleic acids: Carrier of genetic information, Chemical structure of DNA and base composition, Watson-Crick model, Supercoiled DNA, Different forms of RNA: mRNA, tRNA, rRNA and other Types of RNA. Organelle DNA: mitochondria DNA. Chromosome Structure, Chromatin and the Nucleosome: Genome Sequence and Chromosome Diversity, Chromosome Duplication and segregation, The nucleosome, Chromatin structure: euchromatin, heterochromatin, Constitutive and facultative heterochromatin, Regulation of chromatin structure and nucleosome assembly, Nucleolus.

Unit 2 Gene and Genome organization: Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, Histones, Non-histones, Nucleosome, Chromatin, Chromosome structure in prokaryotes & eukaryotes. Basic Processes, Replication of DNA: Prokaryotic and eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Replication errors, DNA damage and their repair.

Unit 3 Transcription and mRNA processing: Prokaryotic &, eukaryotic transcription, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and posttranscriptional gene silencing: Initiation, Elongation & Termination of

transcription, Capping, Polyadenylation, Splicing, editing, mRNA stability, RNA interference, Antisense RNA, Ribozymes Microarray.

Unit 4 Translation: Genetic code, Prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins, suppressors, co-suppressors, moderators, silencers, insulators, enhancers. Operon-lac operon, trp operon, ara operon and gal operon.

Unit 5 Epigenetics and regulation of gene expression: Epigenetic variation, genomic imprinting. Epigenetics in Human Health and diseases Cancer epigenetics, including epigenetic biomarkers in cancer and the emergence of epigenetic therapeutics in cancer treatment.

Recommended Textbooks and References: 1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science. 2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman. 3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.

Human Physiology — Credit hours: 3

Unit: 1 Digestive system: Digestion, absorption, Regulation of Swallowing and Gastric Emptying and Small/ Large Bowel. Gastro-intestinal Secretions and accessory glands and energy balance, BMR.

Respiratory system: Anatomical considerations, Transport of gases, Exchange of gases, Waste elimination, Neural and chemical regulation of respiration. Alveolar Ventilation, Diffusion Across Alveoli. Transport of Respiratory Gases in Blood. The Respiratory System under Stress: Altitude, Hypoxia

Unit: 2 Cardiovascular system: Comparative anatomy of heart structure, Myogenic heart, specialized tissue, Cardiac cycle, Heart as a pump, blood pressure, neural and chemical regulation of all above, Blood cell synthesis and Bone marrow, Haemopoiesis and formed elements, Plasma function, Blood volume and its regulation, Blood groups, Haemoglobin,.

Unit: 3 Excretory system: Comparative physiology of excretion, Kidney, Urine formation, Urine concentration, Waste elimination, Micturition, Regulation of water balance, Electrolyte and acid-base balance.

Nervous system: Neurons, action potential, Gross neuroanatomy of the brain and spinal cord, Central and peripheral nervous system, Neural control of muscle tone and posture. Sense organs: Vision, hearing and tactile response. Thermoregulation and stress adaptation: Comfort zone, Body temperature – physical, chemical, Neural regulation.

Unit: 4 Endocrinology: Endocrine glands, Hormone Structure and Function, Basic mechanism of hormone action, Hormones and diseases, Reproductive processes, Neuroendocrine regulation.

Reproduction Growth and Ageing: Males and female reproductive system. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals. Disorders of normal growth, Abnormalities of fetal and postnatal growth, Physiology of ageing: Changes in various systems and mechanisms involved, factors affecting ageing. Apoptosis

Suggested Reading: 1. Guyton. (2007). Textbook of medical physiology. 11th Edition. Elsevier India Pvt. Ltd. NewDelhi. 2. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). Animal Physiology. Sinauer AssociatesInc. USA. 3. Khurana. (2006). Textbook of Medical Physiology. Elsevier India Pvt. Ltd. 4. Murray, R.K. (2009). Harper's Illustrated Biochemistry. Jaypee Publishers, New Delhi,India. 5. Tyagi, P. (2009). A Textbook of Animal Physiology. Dominant Publishers and distributors,New Delhi, India.

Molecular Biology and Genetic Engineering laboratory — Credit hours: 2

1. Concept of lac-operon:
    a) Lactose induction of B-galactosidase.
    b) Glucose Repression.
    c) Diauxic growth curve of E.coli
2. UV mutagenesis to isolate amino acid auxotroph
3. Phage titre with epsilon phage/M13
4. Genetic Transfer-Conjugation, gene mapping
5. Plasmid DNA isolation and DNA quantitation
6. Restriction Enzyme digestion of plasmid DNA
7. Agarose gel electrophoresis
8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
9. Vector and Insert Ligation
10. Preparation of competent cells
11. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency
12. Confirmation of the insert by Colony PCR and Restriction mapping
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis.
14. Purification of His-Tagged protein on Ni-NTA columns
    a) Random Primer labeling
    b) Southern hybridization.

Recommended Textbooks and References: 1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Immunology **Credit hours: 2**

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

SEMESTER III

Host-Microbes Interaction — Credit hours: 3

Unit I Molecular basis of Infectious Diseases Principles of Infectious Diseases: general principles of microbial interactions with humans that result in infection and diseases; examples of bacterial, viral, fungal and parasitological pathogens with special emphasis in developing countries; molecular basis of bacterial pathogenesis: Role of virulence factors, adhesins, pathogenicity island, protein and DNA secreting systems in pathogenicity and disease;

Unit II modulation of host signaling system in response to infection: molecular and cellular basis of viral infections: key examples of RNA and DNA viruses of humans causing diseases; molecular biology of tumor viruses; mechanisms of viral carcinogenesis;

Unit III molecular parasitology: The molecular aspects of parasite biology, genetics and biochemistry; mechanisms of pathogenesis, parasite adaptations for survival within the host; grand challenges for drug and vaccine development and disease control in infectious diseases.

Unit IV Host - Microbe Relationships: Microbial Colonization of Epithelial Surfaces; bacterial biofilms and Quorum Sensing in health and disease. Epithelial host defense: sensors of extracellular colonization by bacteria, intracellular invasion; signaling pathways and effectors of innate immune system, mechanisms of immune tolerance and its relationships with host commensals; case studies: Hostmicrobe relationships in inflammatory Bowel Disease, obesity and others.

Recommended Textbooks and References: 1. Bacterial Pathogenesis: A Molecualr Approach: 3rd Edition. Abigail A Salyers. ASM Press.2. Emerging infectious Diseases. Vol. 14. CDC Press 3. Molecular Diagnostics of Infectious Diseases. By Harald H. Kesslar. 4. Medical Microbiology: An Introduction to Infectious Diseases. By John C. Sherris, Kenneth J Ryan et al. Elsivier publication. 5. Bacteriology of Humans: An Ecological Perspective by Michael Wilson. Publisher: WileyBlackwell; 1 edition (May 6, 2008)

Molecular basis of human diseases — Credit hours: 3

Unit I Molecular basis of Pulmo-cardiovasuclar system: Key Principles in Disease: Inflammation and Immune Responses. Pulmonary diseases, pathophysiology of COPD, lung fibrosis and role of inflammation in respiratory dysfunction and their pathology, Cardiovascular Disease Overview: Unanswered questions in atherosclerosis, strokes and Lipid Dysregulation, Diabetes and their treatments and preventions. Research and Clinical Challenges.

Unit II Molecular basis of endocrinology and diabetes system: An overview on molecular Basis of Diseases such as Obesity and Diabetes Mellitus and Diagnosis, in depth pathophysiology and diabetes therapy and prevention, Experimental diabetes therapy and prevention, genetics, basics

of diabetes drug development. Importance of Hypothalamus, Pituitary thyroid, Adrenal Gland. The steroid hormones synthesis, regulation, receptors and effects on target tissues.

Unit III Molecular basis of fundamental reproductive processes: Synthesis and actions of hormones, gametogenesis, fertilization and activation of development, embryogenesis, pathologies of the reproductive tracts, developmental origins of reproductive health and disease, contraception, and infertility. Molecular basis of various gastrointestinal diseases such as ulcerative colitis, The pathogenesis of acute liver disease and role of corticosteroids.

Unit IV Molecular basis of Cancer: An overview on mechanism by which cancer develops, grow and spread, Modulation of cell cycle in cancer, Different forms of cancers, Cancer screening and early detection, Detection using biochemical assays, tumor markers, molecular tools for early diagnosis of cancer, Signal targets and cancer Activation of kinases, proto oncogenes and oncogenes activity, Single Nucleotide Polymorphism (SNP) in cancer, Molecular tools for identifying cancer genes, Advances in cancer detection, Use of signal targets towards cancer therapy.

Recommended Textbooks and References: 1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). Molecular Biology of the cell. Garland publishers, Oxford. 2. Celis, J.E. (2006). Cell biology: A laboratory handbook, Vol 1, 2. 3. Academic Press, UK. 3. Gupta, P.K. (2008). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India. 4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India

Animal Biotechnology — Credit hours: 3

Unit 1 Animal tissue culture: Types of culture, culture environment. Basic techniques of cell cultures: Primary and secondary cell culture, Adult and embryonic stem cell culture, Growth factors used in culture, subculture and propagation, immortalization of cell lines. Characterization and quantification of Cell line: Direct and indirect methods for quantification, characterization of cultured cells, morphology, phases of cell growth. Cloning of Cell Lines, Organ/Embryo Culture. Cryopreservation and contamination: Need of cryopreservation, source of contamination, eradication of contamination and cross-contamination. ; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Unit II Animal reproductive biotechnology: Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species, molecular farming" and "pharmaceutical.

Unit III Applications of Animal Biotechnology: Genetic engineering of animal cell cultures, Large Scale Animal Cell Cultures, Production of therapeutic proteins, antibodies, Bioreactors, tissue engineering, In-vitro and In vivo disease models for research.

Unit IV Cloning of Animals (Methods and Applications): Methods of gene Transfer: Chemical, physical and viral gene transfer methods, somatic cell nuclear transfer, Therapeutic and Reproductive cloning, Cloning for Production of Transgenic Animals, transgenic fishes, transgenic birds, cattle, Transgenesis in the improvement of production of traits, Human Cloning,

Recommended Textbooks and References: 1. Animal Cell Culture by John R.W. Masters, Oxford University Press 2. Introduction to Cell and Tissue Culture, Jennie P. Mather and Penelope E. Roberts, Plenum Press, New York and London 3. Molecular Biotechnology by Primrose, Wiley 4. Animal Cell Biotechnology by R.E. Spier and J.B. Griffiths, Academic press. 5. Textbook of Biotechnology by H.K. Das, Wiley India

Stem Cell Biology and Regenerative Medicine — Credit hours: 3

Unit I Introduction to Stem Cells: History and timeline stem cell research. Types of Stem Cells. Cellular complexities: Evolution from single cell life to complex multicellular organisms, cell differentiation, cellular microenvironment, different types of human cells, Stem cells and therapeutics:

Unit II Embryonic stem cell and applications: General properties of embryonic stem cells. Isolation and cultivation of embryonic stem cells (human and mouse) in vitro, precaution and limitation of culturing of embryonic stem cells. Intracellular and cell surface marker of embryonic stem cells. Induced Pluripotent Stem Cells, Application of Embryonic stem cells. 10 hours

Unit III Adult stem Cell and applications: Phenotype and general properties adult Stem Cells like Bone marrow stem cells, Mesenchymal Stem Cells, Endothelial Progenitor Cells, Cord blood stem cells, Tissue-specific stem cells. Plasticity of adult stem cells. Adult stem cell markers. Culture and propagation of adult stem cell in vitro. Applications and Limitations. 11 hours

Unit IV Regenerative Medicine: Stem cell in Gene therapy and tissue engineering. Regenerative medicine, therapeutic cloning and reproductive cloning. Applications and limitations of stem cell cloning. Stem cells applications in treating various diseases like diabetes, RA, Parkinson's, Spinal cord injuries, anti-cancer, heart infarction, vision and hearing repair, skin grafting and wound healing

Unit V Ethical concerns: Ethical issues, challenges, recommendations and current regulations of human stem cell research. Ethical considerations of using embryonic stem cells and limitation of stem cell therapy.

Recommended Textbooks and References: 1. Lanza, R., Gearhart,J. (2009). Essential of Stem Cell Biology. Elsevier Academic Press. 2. Lanza, R., Klimanskaya, I. (2009). Essential Stem Cells Methods. Academic Press. 3. Mao, J. J., Vunjak-Novakovic (2008). Translational Approaches in Tissue Engineering & Regenerative Medicine. Artech House INC Publications 4. Regenerative medicine stem cells and their applications, written by K.R.S. Sambasiva Rao and K. Ananda Krishna, 2010. 5. Culture of human stem cells, written by R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach, Wiley & sons, New Jersey, 2007.

Molecular Toxicology, Therapeutics and Diagnostic — Credit hours: 3

Unit I Molecular Toxicology: Introduction, Passage of chemical through the body, Absorption, Distribution, Metabolism, Excretion, Phase I and Phase II Metabolism in Toxicology, Response to toxicity: Immediate response to toxic insult, Chemical-mediated signalling, Genotoxicity, Repair of cellular damage (DNA and protein repair), Apoptosis and Necrosis, Nephrotoxicity, Hepatotoxicity, Neurotoxicity, Teratogenesis.

Unit II Agonists, antagonists, potency and efficacy: Drug-receptor interactions, stereospecificity and selectivity in drug action and design. Identification of therapeutic targets and rational drug design. Pharmacokinetics, pharmacodynamics, pharmacogenetics and pharmacogenomics. Case studies on drug action and design.

Unit III Molecular pharmacology: Vector engineering, Translational medicine: New approaches, Disease models (in vitro, in vivo and in silico), Biomarkers. Targeted therapy – development of new drugs: identification of new molecular targets, high-throughput screening, risk/benefit ratio, economical and ethical aspects in the development of new drugs. Principles of biological therapy – monoclonal antibodies, small inhibitors – rational drug design, drug transport (liposomes, immunoglobulins, nano-technologies and supramolecular systems). Strategies for immunotherapy (cytokine and vaccine therapy). Antiviral chemotherapy. Actions of cytotoxic drugs: alkylating agents, antimetabolites, antibiotics, mitotic inhibitors, enzymes and hormones.

Unit IV Genome: resolution, detection & analysis: PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis. Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms. Detection and identity of microbial and inherited diseases

Unit V Molecular Oncology & Quality assurance and Control: Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and

melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.

Recommended Textbooks and References: 1. Molecular Toxicology. By David Josephy and Bengt Mannervik. Oxford University Press, 2006. 2. Molecular Toxicology. By Nick Plant. BIOS Scientific Publishers. Taylor and Francis group. 2003. 3. Essential Concepts in Toxicology by Prof P K Gupta. PharmaMed Press.2014 4. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings. 5. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill. 6. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press. 7. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

Intellectual Property Rights, Biosafety and Bioethics — Credit hours: 2

Unit I Introduction to IPR: Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit II Patenting: Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application-forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patentingintroduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement-meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

Unit III Biosafety: Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic

plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV National and international regulations: International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

Unit V Bioethics: Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Recommended Textbooks and References: 1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub. 2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI 3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. 4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. 5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/ 6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press 7. World Trade Organisation. http://www.wto.org 8. World Intellectual Property Organisation. http://www.wipo.int 9. International Union for the Protection of New Varieties of Plants. http://www.upov.int 10. National Portal of India. http://www.archive.india.gov.in 11. National Biodiversity Authority. http://www.nbaindia.org 12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf 13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9 14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8

Bioinformatics Lab — Credit hours: 2

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

Molecular Diagnostic & Pathology lab — Credit hours: 2

1. Introduction to Basic Concepts in Pathology, Pathology of Infections (Bacterial, Fungal and Viral etc.) and biological alterations in different part of the body.
2. Biosafety procedure and ethical concerns for pathology lab practice.
3. Test of accuracy, sensitivity and specificity of the diagnostic test.
4. To estimate presence of glucose in urine/blood using Benedict's test.
5. Preparation and Identification of animal permanent slides using microscopy.
6. Identification of different blood cells using Leishman Staining.
7. To perform histopathology technique using animal tissues.
8. Examination of urine sample for infection.
9. Isolation and identification of microflora from the human body
10. To check the drug tolerance/ resistance against the microbes.
11. PCR for identification of bacterial infection.
12. Western blotting or ELISA to check the latent infection in the human body.

Recommended Textbooks and References: 1. Pathology by Alan Stevens and James Lowe, Elsivier Publication 2. Pathology by Arthur S. Schneider, Lippincott Williams & Wilkins Publications

***More practicals may be added/modified from time to time depending on available facilities / faculties.**

Dissertation I **Credit hours: 4**

Course Objectives: Students should be able to demonstrate the following abilities: Formulate a scientific question; Present scientific approach to solve the problem; Interpret, discuss and communicate scientific results in written form; At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical problem particular diseases in national interest or Indian subcontinent.

SEMESTER IV

Dissertation II **Credit hours: 24**

Course Objectives: The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.