Syllabus for PhD Course work in Biotechnology (2012-13)

BT/Ph1: Research Methodology (5 Credits)

01. Research Methodology (8L):

- Literature review, Defining the research question
- Approaches and Methodology,
- Documentation and presentation of data,
- Analysis and interpretation of data, manuscript preparation

02. Quantitative methods (7L): biostatistics used for analysis of data

03. Computer application and Bioinformatics (10L):

- Introduction: Aim and branches of Bioinformatics, Application of Bioinformatics, Role of internet and www in bioinformatics, Forms of biological information, Types of Nucleotide Sequence: Genomic DNA, Complementary DNA (cDNA),Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs).
- Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB, DDBJ: The knowledge of databases and bioinformatics tools available at these resources. Open access bibliographic resources and literature databases: PubMed, BioMeb Central, Public Library of Sciences (PIoS), CiteXplore.
- Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; Structure Databases: PDB, NDB, PubChem, ChemBank, Sequence file formats: Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. Protein and nucleic acid properties: Various tools at the ExPASy server, GCG utilities and EMBOSS, Computation of various parameters.
- Sequence Analysis: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues Scoring matrices: basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles.
- Sequence alignment: Measurement of sequence similarity; Similarity and homology. Pairwise sequence alignment: Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of

results.bioinformatics, databases and their applications, Drug design and delivery

04. Tools and techniques (20L):

- Biochemical and Biophysical techniques, Microscopic techniques, Histology and histochemistry, Cell biology, molecular biology, Genetic engineering techniques.
- Techniques used for purification and characterization of biomolecules: Centrifugation, Ultrafiltration, Chromatography, electrophoresis, spectrophotometry, GC-MS, LCMS, NMR, MALDITOF, X-ray crystallography, CD
- Microscopic techniques including Fluorescence microscopy, Confocal microscopy, Atomic force microscopy and live cell imaging FACS analysis
- Histology and histochemistry: Fixation and sectioning of tissue, embryos and cells. Immunohistochemistry, immunofluorescence, histochemical staining for characterization of cell type.
- Real time PCR, DNA microarray, New generation DNA sequencing, Protein Microarray, protein sequencing, FRET analysis
- Mass spectrometry based proteomics, mapping of protein interactions using mass spectrometry based approaches,Mass spectrometry based quantitative proteomics (ICAT, ITRAQ, SILAC approaches), Biomarker discovery using mass spectrometry based proteomics.

05. Review writing (1C): Topic of the review should be different than that of the Ph.D.

BT/Ph2 & BT/Ph3 (10C) *(Any 10 credits to be taken from among these optional modules)*

01. Biodiversity and Molecular phylogeny (1C):

- Biodiversity, genetic diversity, molecular diversity and taxonomy, DNA bar-coding, population genetics, conservation of diversity and endangered species.
- Evolution, Modern tools of Taxonomy (alpha beta and gamma level taxonomy), Application of molecular and computational tools for phylogeny, Effects of man-made alteration on biosphere.

02. Stem Cell Biology and Regenerative medicine (1C):

- Introduction to Stem Cells , Reprogramming of Somatic Cells to induced pluripotent Stem cells, Application of iPS technology to Regenerative Medicine.
- Developmental hematopoiesis, Epigenetic regulation of stem cell fate, Niche biology: regulation of hematopoiesis by the nice-mediated signaling mechanisms.
- Cryopreservation of cells (general), Cord blood banking and long-term storage of stem cells, FACS and its application in stem cell research.
- Neural stem cells and differentiation.
- Bone and cartilage biology.
- Embryonic stem cells, Cancer stem cells.

03. Introduction to Virology (1C):

- Classification of viruses
- Virus structure and virus replication
- Epidemiology
- Antivirals, viral vaccines
- Emerging viruses, viral diagnosis
- Viral immunology
- Isolation, detection and characterization of viruses
- Identification of vectors associated with viral diseases

04. Cancer Biology (1C):

- Cell cycle regulation, apoptosis, autophagy, senescence, Hallmarks of cancer.
- Genomic instability, angiogenesis and metastasis.
- Oncogenes and tumor suppressors.
- Gene Regulation and epigenetics.
- Cellular signalling in Cancer.
- Cancer stem cell; Molecular classification of cancer and cancer biomarkers; Cancer therapeutics; Cancer Immunotherapy; Animal model in cancer (Animal facility visit); Histopathology in cancer diagnosis and prognosis.

05. Advance and Applied Immunology (2C)

- Antibodies: Generation of monoclonal and polyclonal antibodies, recombinant approaches to generate monoclonal antibodies, Application of antibodies, abzymes (Catmab), immunotoxins, Single domain antibodies (Nanobody), bivalent and bi-specific antibodies.

- Autoimmunity and tolerance: General principle of autoimmune diseases, mechanism of peripheral and central tolerance, regulatory circuits in autoimmune processes, systemic autoimmune diseases, organ-specific autoimmune diseases (Central nervous system, gastrointestinal, Endocrine, Hepatic, cutaneous and rheumatoid arthritis).
- Transplantation immunology: History, principles and discovery of immunogenetics, donor antigens, mechanism of graft rejection, graft versus host diseases, physiological interaction that modulates graft rejection, manipulations to prevent graft rejection (strategies to induce central and peripheral tolerance). transplantation of specific organs (kidney, liver, heart, lung, pancreas), hematopoietic cell transplantation, xenogeneic transplantation, immunological issues in clinical transplantation.
- Tumor Immunology: Tumor recognition by immune cells, tumor antigens and its identification, Immunosuppression in tumor microenvironments, tumor escape mechanism. Influence of immune system on tumor development, immunoediting, Cancer immunotherapies. NK cell and dendritic cell therapy.
- Vaccines: History, key principle of vaccinology, herd immunity, adjuvants, type of adjuvants, function of adjuvants, classification of vaccines, type of vaccines. New approaches to vaccine design, bacterial vaccines, viral vaccines, T-cell based vaccines, vaccine against parasitic diseases, adverse effects of vaccines. T cell and B-cell epitope mapping.
- Biologics and molecular medicine in immunology (cytokines, chemokines, cell-adhesion molecules, co-stimulatory molecules and surface receptor and ligands as therapeutic targets). Role of non-coding RNA in immune regulation.
- Advance immunological techniques: Flow cytometry, Magnetic sorting, MHC tetramer technology, muliplex assays. Antibody purification and protein conjugations, spectratyping, surface plasmon resonance (SPR).
- Animal model of immunological diseases (Transgenic and knockout animals). Generation of bone-marrow chimeras, humanized mice, parabiosis.

06. Structural Biology (2C):

a) Biophysical Techniques

- Over view of spectroscopy, Electromagnetic and quantum theory of radiation, Wave – particle duality, Photons, Interaction of light with matter , Transition dipole moment, Jablonsky diagram, Beer – Lamberts law;
- UV – visible absorption spectroscopy: applications of UV – visible for estimation of protein. DNA and RNA, enzyme kinetics: protein – ligand interaction.

- Fluorescence spectroscopy of Biomolecules: quantum yield, static and dynamic quenching of fluorescence, energy transfer, polarization , anisotropy, time resolved fluorescence, application to biomolecule structure and dynamics, Protein- ligand interaction
- Circular dichroism spectroscopy and its application for studying the secondary and tertiary structure of proteins;
- Diffraction of x-rays and Braggs law, Surface Plasmon spectroscopy, Electron Microscopy of Biomolecules.

b) Understanding Biology through Protein Structure

- Introduction and general overview
- Covalent structure of proteins, folds and domains
- Techniques of structure determination: Crystallography
- Principles that govern protein structure and stability
- Understanding Immune recognition
- Transport through Membranes
- Protein : Nucleic acid recognition, general principles
- Structure – based drug design: overview
- Structural basis of allostery: general examples
- Assignment and presentation by students

07. Microbiol Ecology and systematics (2C):

- What is Microbial Systematics? concept of Identification, Nomenclature and Classification
- The Species concept
- Importance of morphological, biochemical and physiological differences for species delineation concept of Chemotaxonomy and use of membrane fatty acids, lipid, protein, quinone, peptidoglycan as biomarker
- Molecular chronometers in phylogeny: single gene & multi-gene sequence based microbial typing
- Concept of diversity (α, β & ϒ), calculation of diversity indices (richness and evenness) and rarefaction analysis.
- Techniques used in microbial ecology.
- Modern approaches to study microbial diversity: Omics in diversity analysis (metagenomics + metaproteomics + metatrancriptomics).
- Collection of ecological samples for community analysis.
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- Collection of ecological samples for community analysis.
- Whole genome comparisons. Tree-building algorithms: distance-matrix methods, minimum evolution, LS, maximum parsimony, maximum likelihood and Bayesian inference
- Tree nomenclature: tree rooting, trees and distances, trees and character evolution, gene trees and species trees, consensus trees
- Model fitting and hypothesis testing
- Sources and types of errors in phylogenetic inference
- Preserving and Exploiting Microbial Resources:

08. Nanobiotechnology (2C):

- Introduction, Definitions and historical evolution (colloids etc.) and current practice
- Types of nanomaterials and their classifications (1D, 2D and 3D etc. Nanocrystal, Nanoparticle, Quantum dot, Quantum Wire and Quantum Well etc))
- Physical and Chemical Fundamentals of Nanomaterials
- Overview of synthetic methods
- Surfactants, polymers, emulsions. Micelles/reverse micelles and colloids
- Biological Methods
- Properties and Characterizations
- Applications of Nano-Materials in Biosystems
- Proteins - Lipids - RNA and DNA
- Protein Targeting - Small Molecule/Nanomaterial - Protein Interactions
- Nanomaterial-Cell interactions-Manifestations of Surface Modification (Polyvalency)
- Nanomaterials and Diagnostics/Drug Delivery and Therapeutics
- Nanomaterials and Toxicity Evaluation

09. Biosafety and Bioethics (1C):

a) **Guidelines for Biosafety**, Institutional Biosafety committee, Institutional Animal ethics committee, Institutional ethics committee

b) **Patents and Intellectual property rights**

c) **Bioethics (Animal, Human), Human cloning**

10. Advances in Molecular Biology and Genetic Engineering (2C):

- Genome projects- Human Genome project
- Gene therapy: Introduction, vectors in gene therapy, advances in gene therapy, safety assurances
- DNA analysis and diagnostics: Methods of DNA analysis, Diagnosing infectious diseases, Identifying genetic disease Transgenic animals: custom made animals, Animal bioreactors
- Medical forensics: DNA fingerprinting, - genetic identification, Use of technology in anthropological studies
- Pharmaceutical products of DNA technology: Human protein replacements, Human therapies, Vaccines- traditional vaccines and DNA vaccines
- Agriculture: Enhancing resistance in plants to pathogens, Genetically modified foods

11. Genomics and Proteomics (2C):

- Genome mapping- Genetic mapping, Physical mapping, Resolution of mapping
- Strategies for Sequencing whole genome and sequence data analysis
- Comparative Genomics
- Global expression profiling : whole genome analysis of mRNA and protein expression, microarray analysis and their applications
- Importance of proteomics
- Strategies in proteomics: 2D PAGE and Mass spectrometry
- Database and search engines in proteomics
- Mapping of protein interactions: two hybrid, phage display
- Applications of proteomics: Understanding mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins

12. History of Science (1C):

- Evolution of humans as a knowledge-creating, knowledge seeking species. Knowledge and belief systems in primitive societies. Growth of science as development of conceptual schemes. Science and technology in ancient and medieval civilizations: Babylonia, Egypt, Greece, China, India, Arabs. Origins and growth of mathematics and statistical inference. Role of empirical validation in development of scientific method.

Development of experimental method. Hypothetico-deductive method of science. Role of new tools in growth of science. Case studies of growth of astronomy, chemistry, understanding of earth as a system, evolution of life. Development of intellectual property rights. Modern ICT and collaborative science. Folk knowledge and scientific knowledge. Hallmarks of good science: novelty, synthesis of different streams of knowledge, resolution of paradoxes, practical applications.

BT/Ph4: Field work, Seminar and other academic activities (5C)

01. **Communication skills including writing a research proposal and Seminar presentation** (4C)

02. **Design and teach one practical (experiment) to the M.Sc. students/Teach and monitor an experiment to your junior colleague in the lab** (1C)