BINC SYLLABUS for Paper-I

BINC BioInformatics Syllabus - Basic

Major Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB

The knowledge of various databases and bioinformatics tools available at these resources, organization of databases: data contents and formats, purpose and utility in Life Sciences

Open access bibliographic resources and literature databases:

Open access bibliographic resources related to Life Sciences viz., PubMed, BioMed Central, Public Library of Sciences (PLoS)

Sequence databases

Formats, querying and retrieval

Nucleic acid sequence databases: GenBank, EMBL, DDBJ;

Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, PIR-PSD

Repositories for high throughput genomic sequences: EST, STS GSS, etc.;

Genome Databases at NCBI, EBI, TIGR, SANGER

Viral Genomes

Archeal and Bacterial Genomes;

Eukaryotic genomes with special reference to model organisms (Yeast, Drosophila, C. elegans, Rat, Mouse, Human, plants such as Arabidopsis thaliana, Rice, etc.)

3D Structure Database: PDB, NDB

Chemical Structure database: Pubchem

Gene Expression database: GEO, SAGE

Derived Databases

Knowledge of the following databases with respect to: basic concept of derived databases,sources of primary data and basic principles of the method for deriving the secondary data, organization of data, contents and formats of database entries, identification of patterns in given sequences and interpretation of the same

Sequence: InterPro, Prosite, Pfam, ProDom, Gene Ontology

Structure classification database: CATH,SCOP, FSSP

Protein-Protein interaction database: STRING

Compilation of resources: NAR Database and Web server Issues and other resources published in Bioinformatics related journals

Sequence Analysis

File formats: Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc

Basic concepts: Sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues

Scoring matrices: Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, principles based on which these matrices are derived

Pairwise sequence alignments: Basic concepts of sequence alignment: local and global alignments, 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

Multiple sequence alignments (MSA): The need for MSA, basic concepts of various approaches forMSA (e.g. progressive, hierarchical etc.). Algorithm of CLUSTALW and PileUp and their application for sequence analysis (including interpretation of results), concept of dendrogram and its interpretation

Database Searches:

Keyword-based searches using tools like ENTREZ and SRS

Sequence-based searches: BLAST and FASTA

Sequence patterns and profiles: Basic concept and definition of sequence patterns, motifs andprofiles, various types of pattern representations viz. consensus, regular expression (Prosite-

type) and sequence profiles; profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches

Taxonomy and phylogeny: Basic concepts in systematics, taxonomy and phylogeny; molecular evolution; nature of data used in Taxonomy and Phylogeny, Phylogenetic tree and its reconstruction.

Protein and nucleic acid properties: Computation of various parameters using proteomics tools at the ExPASy server and EMBOSS

Comparative genomics: Basic concepts and applications, whole genome alignments: understanding significance. Artemis as an example

Structural Biology

3-D structure visualization and simulation: Visualization of structures using Rasmol or SPDBV or CHIME or VMD

Basic concepts in molecular modeling: different types of computer representations of molecules. External coordinates and Internal Coordinates

Non-Covalent Interactions and their role in Biomolecular structure and function

Fundamentals of Receptor-ligand interactions.

Proteins: Principles of protein structure; Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure – Primary. Secondary, Super secondary, Tertiary and Quaternary structure; Hydrophobicity of amino acids, Packing of protein structure, Structures of oligomeric proteins and study of interaction interfaces

DNA and RNA: types of base pairing – Watson-Crick and Hoogsteen; types of double helices (A, B, Z), triple and quadruple stranded DNA structures, geometrical as well as structural features; structural and geometrical parameters of each form and their comparison; various types of interactions of DNA with proteins, small molecules

RNA secondary and tertiary structures, t-RNA tertiary structure

Carbohydrates: The various building blocks (monosaccharides), configurations and conformations of the building blocks; formations of polysaccharides and structural diversity due to the different types of linkages
Glyco-conjugates: various types of glycolipids and glycoproteins

Classification and comparison of protein 3D structures:

Purpose of 3-D structure comparison and concepts, Algorithms: CE, VAST and DALI, concept of coordinate transformation, RMSD, Z-score for structural comparison.

Databases of structure-based classification; CATH, SCOP and FSSP

Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods; nearest neighbor and machine learning based methods, analysis of results and measuring the accuracy of predictions.

Tertiary Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative Modeling, fold recognition, threading approaches, and *ab initio* structure prediction methods

Suggested Books for Reading:

David W Mount**,** Bioinformatics: Sequence and Genome Analysis, 2nd Edition, cold Spring Harbor Press

Durbin et al (2007) Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids Cambridge University Press.

Stuart M.Brown (2013) Next-generation DNA sequencing Informatics. Cold Spring Harbor Press

M.E.J. Newman (2010) Networks: An Introduction, Oxford University Press.

Thomas E. Creighton, Proteins: structures and molecular properties

Chemoinformatics Edited by Johann Gasteiger and Thomas Engel

Structural Bioinformatics, Edited Philip E. Bourne and Helge Weissig

Lee A Segel (2008), Biological Kinetics, Cambridge University Press, Cambridge

Cornish-Bowden (2012), Fundamentals of Enzyme Kinetics ,Wiley-Blackwell

Alberghina L (2005), System Biology : Definitions and Perspectives, Springer-Verlag Berlin Heidelberg.

Najarian K, Najarian S, Gharibzadeh S, Eichelberger CN (2009) Systems Biology and Bioinformatics: A Computational Approach, CRC Press.

Klipp E, Liebermeister W, Wierling C, Kowald A, Lehrach H, Herwig R (2009) Systems Biology : A Text Book, Wiley-Blackwell

Integrative approaches for finding modular structure in biological networks, NATURE REVIEWS , GENETICS, VOLUME 14, OCTOBER 2013

BIOINFORMATICS, Vol. 19 no. 2, 2003

Nucleic Acids Research (2014), Vol. 42, Database issue D199–D205 doi:10.1093/nar/gkt1076

Nucleic Acids Research (2012), Vol. 40, Database issue D109–D114 doi:10.1093/nar/gkr988

An extended bioreaction database that significantly improves reconstruction and analysis of genome-scale metabolic networks (2011), Integrative Biology, 2011.3, 1071-1086.

Computational Systems Bioinformatics — Methods and Biomedical Applications By Xiaobo Zhou (Harvard Medical School and Brigham & Women's Hospital, USA), Stephen T C Wong (Harvard Medical School and Brigham & Women's Hospital, USA).

Bioinformatics for Systems Biology (2009) by Stephen Krawetz, Published by Humana Press.

BINC Biology Syllabus: Basic

Cell Biology and Genetics

Basic aspects of Prokaryotic and eukaryotic cells (plant and animal cells); membranes and cellular compartments, cell organelles, structure and function, visualizing cells.

Cell motility and shape: cytoskeletal elements, cilia and flagella; motor proteins

Cell-cell interactions: Intercellular junctions

Cell cycle and its regulation, events during mitosis and meiosis, Programmed Cell Death.

Concepts of Bioenergetics, respiration, electron transport systems.

Concepts of gene: Allele, multiple alleles, pseudoallele, complementation tests.

Mendelian principles: Inheritance, sex linked inheritance, Dominance, segregation, independent assortment.

Mutations: Types, causes and detection, germline versus somatic mutations, Mutant types – lethal, conditional, biochemical, loss of function, gain of function, point/deletion/insertional mutations, DNA repair

Chromosomal Variations: Structural and numerical abnormalities: Aneuploidy, Euploidy, Polypoidy, Trisomy, monosomy, nullisomy.

Basic concepts in immunology, Innate and adaptive, humoral and cell mediated immunity and antigen-antibody interaction

Concepts of development and pattern formation. – C. elegans, Drosophila, Frog embryo development and neural development.

Molecular Biology

DNA and RNA: Structure, physical and chemical properties, Types of DNA and RNA. DNA as a genetic material.

Prokaryotic and eukaryotic genome organization and structure

Basic concepts of replication – Experiments to prove Semi conservative replication, Prokaryotic – rolling circle replication and Eukaryotic replications, Prokaryotic gene expression – Lac operon, trp operan, factors involved in gene regulations, mechanisms of gene expression in Eukaryotes, basic mechanisms of transcription and translation

Mechanisms of genome alterations: Recombination, mutation, inversion, duplication, transposition.

Biochemistry

Carbohydrates and lipids, their importance in cells

Proteins: Amino acids and their physico-chemical properties, peptide bond and peptides

Nucleic acids: Nucleosides, nucleotides, RNA and DNA. Denaturation and renaturation of DNA

Enzymes: Units of activity, coenzymes and metal cofactors, temperature and pH effects, MichaelisMenten kinetics, inhibitors and activators, active site

Carbohydrate metabolism: Glycolysis, gluconeogenesis, glycogenolysis, glycogenesis, TCA cycle and oxidative phosphorylation
Pentose phosphate pathway; hormonal control, β-oxidation and biosynthesis of fatty acids

Transamination and deamination of amino acids, ketogenic and glycogenic amino acids, urea cycle

Purine and pyrimidine biosynthesis

Suggested Books for Reading:

1. Life, the biology of science, 10th edition, David Sadava
2. Genetics: A conceptual approach, 5th Edition, Benjamin Pierce.
3. Principles of Biochemistry by Lehninger
4. The Molecular biology of the Cell, 5th Edition, Bruce Alberts
5. Genes X by B. Lewin
6. Essential Cell Biology 2nd Ed B.Alberts, D.Bray, K.Hopkin and A.Johnson
7. Biochemisty, 6th Edition Berg, Jermy M., Tymoczko, John L and Styer, Lubert
8. Biochemistry Vol 1: Biomolecules, mechanisms of enzyme action and metabolism Voet, D and
   Voet, J.
9. Molecular Biology of the Gene, Watson, JD., Hopkins, NH., Roberts, JW and Steitz, JA

BINC Physical Science syllabus: Basic

Particle dynamics, Newton's laws of motion, velocity, acceleration, momentum. Conservative forces, Conservation of Energy.

First law of thermodynamics, second law of thermodynamics, reversible and irreversible processes, Isothermal, isobaric and quasistatic processes. Concepts of Enthalpy and Entropy, Interrelation between potential energy and force. Thermodynamic, Gibbs and Helmholtz free energies.

Chemical potential. First-order phase transitions

Equation of state for ideal gases. Departures from ideality. Maxwell-Boltzman Distribution

Concept of Reduced Mass

Suggested Books for Reading:

1. Fundamentals of Physics, 6th Edition David Halliday& Robert Resnik
2. The Feynman Lectures on Physics: Volumes 1, 2 & 3

BINC Chemical Science Syllabus: Basic

Hybridization states of atoms. Electronic structure of molecules, Chemical bonding (ionic bonds, covalent bonds, hydrogen bond, hydrophobic effects, coordinate bonds). Basic Molecular orbital theory. Valence bonds. Non-covalent bonding in protein structure.

Tautomerization, geometrical isomerism, inductive effect, Stereochemsitry (R/S, D/L); nucleophile, electrophile, nucleophilic substitution, electrophilic substitution, nomenclature of organic compounds. Bioisosterism.

First law of thermodynamics, isothermal process, entropy and second law of thermodynamics, reversible and irreversible processes; Concepts of enthalpy, internal energy and potential energy; Inter-relation between potential energy and force, heat of formation.

Concept of pH, pK, chemical equilibrium, Henderson-Hasselbach equation, structure of water.

Suggested Books for Reading:

Physical Chemistry, P.W. Atkins and Julio de Paula

Organic Chemistry, Morrison & Boyd.

Biophysical chemistry vol I, Charles R Cantor & Paul Reinhard Schimmel

BINC Mathematics and Statistics Syllabus – Basic

Mathematics

Functions and Graphs of polynomial, logarithm, exponential and trigonometric functions.

2D co-ordinate geometry: Equation of a line, circle, ellipse, parabola, hyperbola; focal point, eccentricity and other properties.

3D geometry: Equation of sphere.

Solution of simultaneous and quadratic equations

Sequences and series.

Limits.

Differentiation and integration of the above mentioned functions.

Matrix algebra: Multiplication, inverse and solution of linear equations.

Statistics

Discrete random variables, their probability mass function, probability distribution function, mean and variance.

Binomial and Poisson random variables and their properties.

Continuous random variable, their probability density function, probability distribution function, mean and variance.

Normal random variables and its properties.

Conditional probability and Bayes' theorem.

Suggested Books for Reading:

Hogg, Mckean and Craig: Introduction mathematical Statistics 6th edition Pearson, Prentice Hall,2005.

Sheldon M. Ross: Introduction to probability models, 9th edition, Academic Press, 2007.

Gilbert Strang: Linear Algebra and its application, 4th edition, Cengage Learning, 2006.

NCERT class 12 mathematics books.

Ewens and Grant: Statistical methods in bioinformatics.

BINC Information Technology Syllabus: Basic

Fundamentals in Computing

Types of Processing: Batch, Real-Time, Online, Offline.

Types of modern computing: Workstations, Servers, Parallel Processing Computing, Cluster computing, Grid computing

Memory and Storage Devices, Network, Internet-Basics

Introduction to operating systems: Operating System concept, UNIX/LINUX.

Basic Programming Concepts – sequential, conditional and loop constructs, Arrays, Strings, Object Oriented Programming Concepts- Classes, Objects, Inheritance, Polymorphism; File Handling

Introduction to Database Systems- SQL Queries

Suggested Books for Reading:

1. Database Management System – Ramakrishnan and Gehrke
2. Data Structure : Andrew S Tannenbaum
3. Complete Reference to C
4. Complete Reference to Java
5. Complete reference to Perl
6. Complete Reference to Python