M.Sc. BIOINFORMATICS

Proposed modifications

REGULATIONS AND SYLLABI
(Effective from 2015-2016)

Centre for Bioinformatics
SCHOOL OF LIFE SCIENCES
PONDICHERRY UNIVERSITY
PUDUCHERRY
Eligibility for M.Sc. Bioinformatics

Students from any of the below listed Bachelor degrees with minimum 55% of marks are eligible.

- Bachelor’s degree in any relevant area of Physics / Chemistry / Computers Science / Life Science/with a minimum of 55% of marks
# LIST OF COMPULSORY HARD-CORE COURSES FOR M.Sc. BIOINFORMATICS

(Academic Year 2015-2016 onwards)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>H</th>
<th>Credits</th>
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<tr>
<td><strong>Semester I</strong></td>
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<tr>
<td>BINF 441</td>
<td>Cell and Molecular Biology</td>
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<td>Bioinformatics Databases</td>
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<td>Genomics and Proteomics</td>
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<td>BINF 492</td>
<td>Bioinformatics: Sequence Analysis</td>
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<td>Lab – Programming in DBMS</td>
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<td>Lab - Biosequence Analysis</td>
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<td>BINF 542</td>
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PONDICHERY UNIVERSITY
SCHOOL OF LIFE SCIENCES
Centre for Bioinformatics
LIST OF SOFT-CORE COURSES FOR M.Sc. BIOINFORMATICS
(Academic Year 2015-2016 onwards)

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<td>BINF 444</td>
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<td>BINF 493</td>
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<td>Microscopic Techniques For Image Processing</td>
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<td>BINF 545</td>
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<td>R language and Bioconductor</td>
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+ Physics, Chemistry and Mathematics are compulsory for students having UG degree in Biological Sciences.

# Essential Soft core for all students of the Centre.

* Exclusively for students from sister departments.
UNIT 1

UNIT 2

UNIT 3
Chloroplast structure and function – An overview of photosynthetic Metabolism – The absorption of light – Photosynthetic units and reaction centers – Photophosphorylation – Carbon dioxide fixation and the synthesis of carbohydrates. Chloroplast and its genome study.

UNIT 4

UNIT 5

Text Books:
2. Genes VIII by Lewin, B. Pearson Education International. 2004
BINF 442 - BIOINFORMATICS DATABASES

Total Credits: 3

Unit 1
Introduction to Bioinformatics data and databases – Types of Biological data: Genomic DNA, Complementary DNA, Recombinant DNA, Expressed sequence tags, Sequence-Tagged Sites, Genomic survey sequences: Primary Databases: GenBank, EMBL, DDBJ; Composite Databases: NRDB, UniProt; Literature Databases: Open access and open sources, PubMed, PLoS, Biomed Central, NAR databases; Bioinformatic Resources: NCBI, EBI, ExPASy, RCSB.

Unit 2
Genome Databases – Viral genome database: ICTVdb; Bacterial Genomes database: Genomes OnLine Database –GOLD, Microbial Genome Database-MBGD; Genome Browsers: Ensembl, VEGA genome browser, NCBI-NCBI map viewer, KEGG, MIPS, UCSC Genome Browser; Archeal Genomics, Eukaryotic genomes with special reference to model organisms: Yeast(SGD), Drosophila (FlyBase), C.elegans (WormBase), Rat, Mouse, Human (OMIM / OMIA), plants – Arabidopsis thaliana (TAIR), Rice, PlasmodiumDB, etc.

Unit 3
Sequence Databases – Nucleotide sequence Databases: GenBank, EMBL, DDBJ; Protein sequences Databases: Swiss-Prot, TrEMBL, UniProt, UniProtKB, UniParc, UniRef, UniMES; Sequence motifs Databases: Prosite, ProDom, Pfam, InterPro, Gene Ontology; Sequence file formats: GenBank, FASTA, PIR, ALN/ClustalW2.

Unit 4

Unit 5

Text Books:
3. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson Education. 1999
BINF 443 – C, C++ AND DATA STRUCTURES

Total Credits: 3
Total: 36 Hrs.

Unit 1 7 lectures

Unit 2 6 lectures
Controls and loops – Conditional and Unconditional Control Statement – Looping Statement: while, do-while, for – nested loop – Arrays.

Unit 3 8 lectures

Unit 4 6 lectures

Unit 5 9 lectures

Text Books:

Total Credits: 3

Unit 1

Unit 2
Quantum Mechanics – Black body radiation, photoelectric effect, Bohr’s Model of Hydrogen atom, De Broglie’s Hypothesis, Harmonic wave function, wave packets, Heisenberg uncertainty principle, eigen states and eigen values, Pauli’s exclusion principle, Schrodinger equation

Unit 3

Unit 4
Electricity – Electrostatic Field: Electric charge, Coulomb’s Law, Electrostatic Field, Electric Field of a point charge, Electric Field from Charge Distribution, forces on charges in electric fields, electric flux, Gauss’s law, Electric field and conductor, The Electric Potential: Electrical Potential Energy, Electric potential, equipotential surface, finding E from V, Potential of a Point Charge and Groups of Points Charges, Potential Due to a Continuous Charge Distribution.

Unit 5
**Text Books:**

**Reference Books:**
Total Credits: 3  
Total: 36 Hrs.

Unit 1  

Unit 2  
Symmetry and Principles – Definitions and theorems of group theory, subgroups, Classes. Molecular symmetry and symmetry groups – symmetry elements and operations. Symmetry planes, reflections, inversion centre, proper/ improper axes of rotation, symmetry elements and optical isomerism, symmetry point groups, classes of symmetry operations, classification of molecular point groups.

Unit 3  
Introduction to Organic chemistry – Carbon and its compounds, Position of Carbon in periodic table, tetra covalency of carbon, catenation, functional groups, formal charge, oxidation number, aromaticity, electrophiles and nucleophiles, organic acids and bases, types of organic reactions.

Unit 4  
Stereochemistry – Concept of isomerism, types of isomerism, optical isomerism, elements of symmetry, molecular chirallity, enantiomers, stereogenic centres, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, distereoisomers, mesocompounds, resolution of enantiomers. Relative and absolute configurations, sequence rules, D & L , R & S systems of nomenclature.

Unit 5  
Heteroaromatics – Five membered and six membered hetero aromatics with one and two hetero atoms and their benannulated analogues, Nucleic acid bases, Structure, name and properties like acid base property, electron rich electron deficient heterocycles, hydrogen bonding etc. (Synthesis and reactions not necessary).

Text Books:  
1. Organic Chemistry by Paula Yurkanis Bruice, Prentice Hall. 2010
BINF 446 - MATHEMATICS

Total Credits: 3  
Total: 36 Hrs.

Unit 1  
6 lectures
Matrices – Properties of Determinants, Minors and Cofactors, Multiplication of Determinants, Adjoint, Reciprocal, Symmetric Determinants, Cramer’s rule, Different types of matrices, Matrix Operations, Transpose of a matrix, Adjoint of a square matrix, Inverse of a matrix, Eigen values and eigen vector

Unit 2  
6 lectures
Trigonometry and Analytical Geometry – Trigonometric ratios, De Moivre’s theorem, The general equation of a Straight line, slope of a line, intercepts of a line, Angle between two lines, Intersection of two lines, The general equation of a Circle.

Unit 3  
8 lectures

Unit 4  
10 lectures

Unit 5  
6 lectures

Text Books:
1. Algebra by Serge A. Lang, Pearson Education. 2003
2. Introduction to Calculus & Analysis, VoI I and II by Richard Courant & Fritz John, Springer publisher. 1999

Reference Books:
1. Basic Mathematics by Serge A. Lang. Springer Publisher. 1988
BINF 447 - BIOLOGY

Total Credits: 2

Total: 24 Hrs.

Unit 1
Diversity in Living World: Diversity of living organisms – Classification of the living organisms (five kingdom classification, major groups and principles of classification within each kingdom). Systematics and binomial System of nomenclature - Salient features of animal (non-chordates up to phylum level and chordates up to class level) and plant (major groups; Angiosperms up to class) linnaean classification.

Unit 2
Structural Organisation in Animals and Plants – Morphology, anatomy and functions of different parts of flowering plants: Root, stem, leaf, inflorescence, flower, fruit and seed. Morphology, anatomy and functions of different systems of an annelid (earthworm), an insect (cockroach) and an amphibian (frog).

Unit 3

Unit 4

Unit 5

Text Book:
1. Molecular Biology of the cell by Bruce Alberts, Garland publishing Inc. 2002

Reference Books:
2. Cell and Molecular Biology by De Robertes and De Robertis. Saunders College, Philadelphia, USA. 2002
BINF 448 - BASICS OF COMPUTER

Total Credits: 2

Unit 1

Unit 2
Network Basics – Communication Technology – Networking Elements: Networking Hardware, Networking services: Types of Networks – LAN, WAN & MAN, Intranet–Wireless communication – Internet services, Uses of Internet

Unit 3
Introduction to Database systems – Fundamentals of database - Database models (Hierarchical, Network, Relational and Object-Oriented Models) – RDBMS: Relational Database Management systems - Database System Applications and Security.

Unit 4

Unit 5
Internet Technologies – Web Services – WWW, URL, Servers: Client/Server essentials - Domain Name Server, FTP server, E-mail server, WEB servers, Web publishing-Browsers-IP Addressing, IPV6

Text Books:

BINF 449 - INTRODUCTION TO BIOINFORMATICS

Total Credits: 3
Total: 36 Hrs.

Unit 1

Introduction – Aim and branches of Bioinformatics, Application of Bioinformatics, Role of internet and www in bioinformatics. Basic biomolecular concepts: Protein and amino acid, DNA & RNA, Sequence, structure and function. Forms of biological information, Types of Nucleotide Sequence: Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs). DNA sequencing methods: Basic and Automated DNA sequencing, DNA sequencing by capillary array and electrophoresis, Gene expression data.

Unit 2

Bioinformatics Resources – NCBI, EBI, ExPASy, RCSB, DDBJ: The knowledge of databases and bioinformatics tools available at these resources, organization of databases: data contents, purpose and utility. Open access bibliographic resources and literature databases: PubMed, BioMed Central, Public Library of Sciences (PloS), CiteXplore.

Unit 3


Unit 4

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.

Unit 5

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.

Text Books:

Reference Book:
1. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, Pearson Education. 1999
2. Bioinformatics for Dummies by Jean-michel Claverie Cedric Notredame. Publisher: Dummies (Jan 2007)
BINF 481 - LAB - CELL AND MOLECULAR BIOLOGY

**Total Credits: 1**

**Exercises in Cell Biology**

- Paper Chromatography of Chlorophyll pigments
- Estimation of Chlorophyll
- Ascorbic acid estimation in different tissues of plants and animals.
- Growth curve of Bacteria.
- Estimation of cell mass of bacteria.

**Exercises in Molecular Biology**

- Isolation & Purification of genomic DNA from bacteria
- Isolation & Purification of plasmid DNA
- Agarose gel electrophoresis of chromosomal & plasmid DNA
- Restriction Digestion of chromosomal & plasmid DNA
- Isolation of DNA fragment from agarose gel
- PCR for DNA amplification
- Protein separation using HPLC (demo)

- Protein separation using SDS-PAGE
BINF 482 - LAB - BIOLOGICAL DATABASES

Total Credits: 1

Exercises:

1. Bioinformatics Resources: NCBI, EBI, DDBJ, RCSB, ExPASy

2. Database search engines: EntrezDBGET

3. Open access bibliographic resources and literature databases
   a. PubMed
   b. BioMed Central
   c. Public Library of Sciences (PloS)
   d. CiteXplore.

4. Bioinformatics Resources at the species level
   a. ICTV Database
   b. AVIS
   c. Viral genomes at NCBI

5. Sequence databases:
   a. Nucleic acid sequence databases: GenBank, EMBL, DDBJ;
   b. Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc;
   c. Repositories for high throughput genomic sequences: EST, STS, GSS.
   d. Genome Databases at NCBI, EBI, TIGR, SANGER


7. Derived Databases: InterPro, Prosite, Pfam, ProDom

8. Sequence file formats: GenBank, FASTA

9. Protein and nucleic acid properties: Proteomics tools at the ExPASy server, EMBOSS
BINF 483 - LAB - BASICS OF COMPUTER & OPERATING SYSTEMS

Total Credits: 1

Exercises:

1. Command Line Interface - Internal Commands - External commands

2. Graphical User Interface: Peer-to-Peer Operating System

3. Client-Server Operating System

4. Software Package:
   a. Create a manuscript using ms-word by applying relevant font styles, margins, bullets and tables.
   b. Prepare a call letter for the admission of MSC bioinformatics to all the selected students by using mail merge.
   c. Prepare a student’s fee table for four semesters in a excel sheet. Calculate the consolidated payment using links.
   d. Create all types of charts using excel for any clinical data.

5. Create a web page for an educational institution using HTML tags.

6. Create a web page to display your details by creating a model web site.
Total Credits: 1

**LINUX Operating System:** Overview of Linux Architecture and Basic commands

**C**
1. Display a protein details using escape sequence
2. Calculate rotations per minute \[ \text{rpm} = 1000 \sqrt[3]{\text{RCF}} / 11.17r \]
3. Create amino acid dictionary using switch construct
4. Identify the glucose level in a blood using if - else if construct
   - The glucose level is identified by
     - <70 – hypoglycemia, 70-180 hyperglycemia, > 180 diabetics
5. Identify the type of two peptides using nested if
   - peptide length is < 8 small, poly otherwise
6. Count the number of base characters entered among n characters using loop
7. Implement stack operation
8. Count the number of positive, negative and zero energy molecules stored in an array
9. Find the transpose of the given matrix using two dimensional array
10. To calculate pH value for a given \([\text{OH}^-]\) concentration \[ \text{pH} = -\log_{10}(\text{OH}^-) \]
11. Draw a line in different pattern using user defined function
12. Write a user defined function to illustrate the storage class of the variables
13. Determine the percentage of a,t,g,c in the given sequence
14. Count the number of gaps in the given sequence using user defined function
15. Sort n names
16. Align two sequences
17. Count the number of motif in the given sequence
18. Swap two numbers using pointers
19. Process the organism details using structure
20. Convert the RNA sequence into DNA sequence using text file

**C++**
1. Create a class which shows the various forms of constructors
2. Inheritance implementation
3. Function overloading example
4. Operator overloading example
5. Dynamic polymorphism implementation
BINF 485 - LAB - BIOINFORMATICS DATABASES AND TOOLS

Total Credits: 1

Exercises:

1. Entrez and Literature Searches.
   a. PubMed
   b. PubMed central
   c. OMIM / OMIA
   d. Citation matcher

2. SRS of Biological Databases
   a. Nucleotide/Genome Databases.
   b. Protein Sequence Database.
   c. Structure databases.
   d. Protein Pattern Databases

3. File format conversion
   a. FmtSeq
   b. ReadSeq
   c. Sequence manipulation Suite

4. Sequence Analysis
   a. Dot Plot
   b. Pairwise alignment
   c. Multiple Sequence Alignment

5. Softwares
   b. GeneDoc
   c. ClustalW / X, MEGA, MEME

6. Visualization Tool
   a. RasMol
   b. Cn3D
   c. MolMol
BINF 491 - GENOMICS AND PROTEOMICS

Total Credits: 3
Total: 36 Hrs.

Unit 1
Genomics and Metagenomics – Large scale genome sequencing strategies. Genome assembly and annotation. Genome databases of Plants, animals and pathogens. Metagenomics: Gene networks: basic concepts, computational model such as Lambda receptor and lac operon. Prediction of genes, promoters, splice sites, regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic genomes and interpretation of results. Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays. Basic concepts in identification of Drought stress response genes, insect resistant genes, nutrition enhancing genes

Unit 2
Epigenetics – DNA microarray: database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases DNA microarray: understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches)

Unit 3
Comparative genomics – Basic concepts and applications, whole genome alignments: understanding the significance; Artemis, BLAST2, MegaBlast algorithms, PipMaker, AVID, Vista, MUMmer, applications of suffix tree in comparative genomics, synteny and gene order comparisons Comparative genomics databases: COG, VOG

Unit 4
Functional genomics – Application of sequence based and structure-based approaches to assignment of gene functions – e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc. Use of various derived databases in function assignment, use of SNPs for identification of genetic traits. Gene/Protein function prediction using Machine learning tools viz. Neural network, SVM etc

Unit 5
Proteomics – Protein arrays: basic principles. Computational methods for identification of polypeptides from mass spectrometry. Protein arrays: bioinformatics-based tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); databases (such as InterPro) and analysis tools. Protein-protein interactions: databases such as DIP, PPI server and tools for analysis of protein-protein interactions

Text Books:

Reference books:
BINF 492 - BIOINFORMATICS: SEQUENCE ANALYSIS

Total Credits: 3
Total: 36 Hrs.

Unit 1

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. Repeats: Tandem and Interspersed repeat finding, Motifs, consensus, position weight matrices

Unit 2

Pairwise sequence alignment – Basic concepts of sequence alignment, gap penalties, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments and application in Nucleic acid and protein sequences alignments.

Multiple sequence alignments (MSA) – The need for MSA, basic concepts of various approaches for MSA (e.g. progressive, hierarchical etc.). Algorithm of CLUSTALW and PileUp and application, concept of dendrogram and its interpretation, Use of HMM-based Algorithm for MSA (e.g. SAM method)

Unit 3

Comparative Genomics – Basic concepts, Applications of Comparative Genomics: Identifications of Protein coding genes, Regulatory Regions, virulence factors / pathogeneity islands; Reconstruction of metabolic pathways, Genome analysis tools : Artemis, MegaBLAST, Geneplot

Unit 4

Sequence patterns and profiles – Basic concept and definition of sequence patterns, motifs and profiles, 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.

Algorithms for derivation and searching sequence patterns – MEME, PHI-BLAST, SCanProsite and PRATT. Algorithms for generation of sequence profiles: Profile Analysis method of Gribskov, HMMer, PSI-BLAST

Unit 5

Taxonomy and phylogeny – Basic concepts in systematics, taxonomy and phylogeny; molecular evolution; nature of data used in Taxonomy and Phylogeny, Definition and description of phylogenetic trees and various types of trees, Phylogenetic analysis algorithms such as maximum Parsimony, UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining, Probabilistic models and associated algorithms such as Probabilistic models of evolution and maximum likelihood algorithm, Bootstrapping methods, use of tools such as Phylip, Mega, PAUP

Text Books:
BINF 493 - PROBABILITY AND STATISTICS

Total Credits: 2

Total: 24 Hrs.

Unit 1
Numerical descriptive techniques – Measures of central tendency: mean, median, mode. Partition values: quartiles, deciles, percentiles; Measures of dispersion: Absolute and Relative Measures, Moments, skewness and kurtosis

Unit 2
Correlation and Regression – Principles of least squares, scatter diagram, correlation, covariance, correlation coefficient, properties of correlation coefficient, regression, properties of linear regression, rank correlation, multiple correlation

Unit 3
Probability Theory – Concept of probability: sample space and events, independent events, mutually exclusive events. axioms of probability, conditional probability, additional and multiplication theorem of probability, Baye's theorem.

Unit 4
Sampling Theory – Meaning and objective of sampling, Sampling Error, Types of Sampling, Sampling Distribution and Sampling Distribution of Sample Mean.

Unit 5
Probability Distribution – Bernoulli trials, binomial distribution, normal distributions, Poisson distribution, Test of Hypothesis of Small and Large Samples- Standard Normal distribution, Chi-square distribution, Student’s t distribution, F distribution, Analysis of Variance

Text Books:


Reference Books:

BIN 494 - PROGRAMMING IN JAVA

Total Credits: 3
Total: 36 Hrs.

Unit 1
Java Basics – Importance and features of java, Modifiers, Access Controls, Data types, Expressions, Declarations, Statements & Control Structures, Program Structures, String handling, Packages, Interfaces, Working with java util Package, Garbage Collection

Unit 2
Exception Handling, I/O & JDBC – Exception Handling: built in exception, creating your own exceptions, Input Stream & Output Stream: Streams, Byte and Character stream, Predefined streams, Reading and Writing from Console and Files, Buffered Reader & Writer, Serialization, Database: JDBC Basics

Unit 3

Unit 4
AWT & Event Handling – Creating User interface with AWT, Applets, Applet Life Cycle, Simple Graphics, Fonts and Colors, Events, Listeners, Components, Containers, Working with LayoutsEvent Classes, Event Listener Interfaces, Adapter and Inner Classes

Unit 5
BioJava – Installing BioJava, Symbols, Basic Sequence Manipulation (DNA to RNA, Reverse Complement, motif as regular expression), Translation (DNA to Protein, Codon to amino acid, Six frame translation), Proteomics (Calculate the mass and pI of a peptide), Sequence I/O (File Formats conversions), Locations and Features (PointLocation, RangeLocation, Feature modifications), BLAST and FASTA (Blast and FastA Parser, extract information from parsed results), Counts and Distributions, Weight Matrices and Dynamic Programming, User Interfaces.

Text Books:

Reference Books:
2. Object Oriented Design and Applications (2nd Ed.) by Benjamin, Cummings and Booch, G., Addison Wesley Publishers. 1994
Total Credits: 3

Unit 1
**Introduction** – Database System Versus File Systems, Characteristics of Database, Database Concepts, Schemas & Instances, DBMS architecture and Data Independence, Data Models, Database Languages & Interfaces, View of Data, Database users and Administrators, Database System Structure, Database System Applications

Unit 2
**Data models** – ER Model: Keys, Constraints, Design Issues, Extended ER features, Reductions of ER Schema to Tables. Relational Model: Structure, Relational Algebra; Hierarchical Model, Network Model, Object Oriented Model

Unit 3
**Structured Query Language** – Basic Structure, Set Operations, Aggregate Functions, Null Values, Nested Sub queries, Views, Integrity: Domain constraints, Joined Relations, Data-Definition Language

Unit 4
**Relational Database and Storage** – Pitfalls in Relational Design Database, Functional dependencies, Decomposition Normal Forms – 1NF, 2NF, 3NF & Boyce-Codd NF, Data Storage – Ordered indices, Hashing concepts - Security and Authorization.

Unit 5

Text Books:

Reference books:
BINF 496 - FUNDAMENTALS OF ALGORITHMS

Total Credits: 3
Total: 36 Hrs.

Unit 1

Unit 2

Unit 3
Graphs – Representation of Graphs, Breadth First Search, Depth First Search, Topological Sort, Connected Components, Minimum Spanning Tree, Single-Source Shortest Path: Dijkstra’s Algorithm, All-Pairs Shortest Paths, Coloring of Graphs

Unit 4
Trees – Forests, DAGs, Ancestors, and Descendants, Binary Search Trees, Querying a Binary search tree, Insertion and Deletion, Tree Traversals, AVL-Trees, Rotations, Insertion, Deletion, B-trees.

Unit 5

Text Books:

Reference Books:
BINF 497 - MICROSCOPIC TECHNIQUES FOR IMAGE PROCESSING

Total Credits: 2
Total: 24 Hrs.

Unit 1

Unit 2
Scanning electron microscopy – Basic systems of the SEM – Contrast and three-dimensionality of the SEM image – Stereo imaging with the SEM

Unit 3


Unit 4
Image processing and image analysis by computer – Capturing the image – Conventional vs. digital – Image processing – Controlling contrast, brightness and gamma – Removing noise – Fast Fourier Transform – images for publication and presentation – Three dimensional imaging.

Unit 5
Atomic Force microscopy and Confocal Microscopy – Atomic force microscopy (AFM) including contact-mode, tapping-mode and lateral-force

AFM
Confocal Microscopy: Basics of Confocal Microscopy, Sample Preparation, Confocal Optics, Resolution.

Text Book:

Reference Books:
Total Credits: 1

Exercise in JAVA

1. Working with Objects, Arrays, Conditionals and Loops.

2. Creating Classes and Applications in Java.

3. Java Exception handling

4. Streams and I/O, Using Native Methods and Libraries

5. Simple Animation and Threads, Advanced Animation, Images and Sound.


7. Local and global alignment of sequences

8. Creating User Interfaces with AWT, Modifiers.

9. Multithreading example

Total Credits: 1

Exercise in DBMS (MYSQL)

Data Definition Language (DDL) statements:
Creating database, Selecting database, Deleting database, Creating table, Modifying Table, Deleting table

Data Manipulation statements:
Inserting, updating and deleting records
Retrieving Records
Retrieving specific rows and columns
Use of MySQL operators – Arithmetic operators, Comparison Operators, Logical operators
Math functions, Aggregate functions
String operations
Limiting, Sorting and grouping query results
Handling null values
Renaming or aliasing table and column names
Using subqueries
Using Joins – joining a table to itself, joining multiple tables
Use of Indexes
Security Management
Granting and Revoking rights on tables
Total Credits: 1

Exercises:

1. Sequence Analysis Packages: EMBOSS, NCBI ToolKit, SMS
2. Pair wise alignment:
   a. Search tools against Databases:
      i. BLAST
      ii. FASTA
3. Multiple sequence alignment:
   a. Clustal
   b. Dialign
   c. Multalign
4. Sequence patterns and profiles:
   a. generation of sequence profiles
      i. PSI-BLAST
   b. derivation of and searching sequence patterns:
      i. MEME/MAST
      ii. PHI-BLAST
      iii. ScAnProsite
      iv. PRATT
5. Protein motif and domain analysis:
   a. MEME/MAST
   b. eMotif
   c. InterproScan
   d. ProSite
   e. ProDom
   f. Pfam
6. Phylogenetic analysis – MEGA, PAUP, PHYLIP
BINF 541 - STRUCTURAL BIOLOGY

Total Credits: 3

Total: 36 Hrs.

Unit 1
8 Lectures


Unit 2
6 Lectures


Unit 3
9 Lectures

Phase Problem – What is phase problem, How to solve the phase problem, Patterson function, Direct methods, Isomorphism replacement method, heavy atom method. Nuclear Magnetic Resonance: Chemical Shift, Coupling constant, spin-spin relaxation, spin-lattice relaxation, COSY, NOESY and NOE.

Unit 4
7 Lectures

Structure Prediction Strategies – Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods; analysis of results and measuring the accuracy of predictions using Q3, Segment overlap, Mathew’s correlation coefficient Identification/assignment of secondary structural elements from the knowledge of 3-D structure of macromolecule using DSSP and STRIDE methods

Unit 5
6 Lectures

Classification and comparison of protein 3D structures – Purpose of 3-D structure comparison and concepts; Algorithms such as FSSP, CE, VAST and DALI, Fold Classes. Databases of structure-based classification: CATH and SCOP. Structures of oligomeric proteins and study of interaction interfaces

Text Books:
1. Molecular Modeling Principles and Applications (2nd Ed.) by Andrew R. Leach., Prentice Hall, USA. 2001
BINF 542 - MOLECULAR MODELING AND DRUG DESIGN

Total Credits: 3
Total: 36 Hrs.

Unit 1 8 Lectures

Unit 2 5 Lectures

Unit 3 8 Lectures
Molecular Dynamics Simulation – Introduction, Radial distribution functions, Pair Correlation function, Newtonian dynamics, Integrators- Leapfrog and Verlet algorithm, Potential truncation and shifted-force potentials, Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations

Unit 4 8 Lectures
Drug design – Drug discovery process. Target identification and validation, lead optimization and validation. Methods and Tools in Computer-aided molecular Design, Analog Based drug design:- Pharmacophores (3D database searching, conformation searches, deriving and using 3D Pharmacophore, constrained systematic search, Genetic Algorithm, clique detection techniques, maximum likelihood method) and QSAR. Structure based drug design:- Docking, De Novo Drug Design (Fragment Placements, Connection Methods, Sequential Grow), Virtual screening.

Unit 5 7 Lectures

Text Books:

Reference:
BINF 543 - PROGRAMMING IN PERL

Total Credit: 3

Unit 1

Unit 2
Modular Programming – Subroutines, Advantage of Subroutines, Scoping and Subroutines, Arguments, Passing Data to Subroutines, Modules and Libraries of Subroutines, Concept about File handle, Opening and Closing a File handle, Opening and Closing a Directory Handle, Reading a Directory Handle, File and Directory Manipulation.

Unit 3
Regular Expression and Perl Special Variables – Concepts about Regular Expressions, Simple uses of Regular Expressions, Patterns, Matching Operator, Substitutions, Split and Join functions.

Unit 4
Common Gateway Interface (CGI) Programming – The CGI.pm Module, CGI program in Context, Simple CGI programs, Passing Parameters via CGI, Perl and the Web

Unit 5
Bioperl – Introduction to Bioperl, Installing procedures, Architectures, General Bioperl Classes, Sequences (Bio:Seq Class, Sequence Manipulation), Features and Location Classes (Extracting CDS), Alignments (AlignIO), Analysis (Blast, Genscan), Databases (Database Classes, Accessing a local database), Implementing REBASE

Text Books:


Total: 36 Hrs.
BINF 544 - SYSTEMS BIOLOGY

Total Credits: 3

Unit 1


Unit 2


Unit 3

Signalling & Experimental methods in systems biology – slow and auto-regulation The coherent FFL and incoherent FFL, single-input module (SIM): LIFO and FIFO, DOR, signaling networks and neuronal circuits.


Unit 4


Unit 5

Synthetic Biology – Introduction, definition and Basics, Synthetic Oligonucleotide/DNA-based, RNA-based, Peptide-based Technologies and Applications, Technologies and Applications of Directed Evolution and Microbial Engineering, Potential Hazards of Synthetic Biology, iGEM.

Text Books:

Reference Books:
BINF 545 - BIOLOGICAL SPECTROSCOPY

Total Credits: 2

Unit 1

Unit 2
Infrared spectroscopy – principle - types of stretching and bending vibrations - vibrational frequencies - instrumentation - block diagram - source - monochromator - cell sampling techniques - detector and recorders - identification of organic molecules from characteristic absorption bands. FTIR and its advantages

Unit 3
Raman spectroscopy – Raleigh and Raman scattering - stoke's and anti stokes lines - instrumentation - block diagram - differences between IR and Raman spectroscopy - mutual exclusion principle - applications - structural diagnosis.

Unit 4
Magnetic Resonance Spectroscopy – Nuclear Magnetic Resonance Spectroscopy- Nuclear spin magnetic moment, Interaction of nuclear magnet with external magnetic field, NMR spectrometer, relaxation and dynamic processes, chemical shift, Heteronuclear NMR experiments.
Electron Spin Resonance Spectroscopy: Electron spin and Magnetic moment, Resonance condition in ESR and significance of 'g' value, applications of ESR.

Unit 5

Text books:
2. Introduction to molecular spectroscopy by G. M. Barrow., McGraw-Hill.1962

Reference Books:
1. Molecular spectroscopy by I. N. Levins, Wiley Interscience. 1975
BINF 546 - DATA MINING AND MACHINE LEARNING

Total Credits: 3

Unit 1
Introduction – Introduction, Importance of Data Mining, Relational Databases, Data Warehouses, Transactional Databases, Advance Database Systems and Applications, Data Mining Functionalities, Classification of Data Mining Systems, Major issues in Data Mining.

Unit 2
Primitives and System Architectures – Data Mining Primitives, Data Mining Query Language, Designing Graphical User, Interfaces Based on a Data Mining Query Language, Architectures of Data Mining Systems.

Unit 3
Concept Description and Association Rules – Concept Description, Characterization and comparison, Data Generalization and Summarization-Based Characterization, Analytical Characterization, Mining Class Comparisons, Mining Association Rules in Large Databases, Association Rule Mining, Mining Single-Dimensional Boolean Association Rules from Transactional Databases.

Unit 4
Classification and Prediction – Classification and Prediction, Issues: Data preparation for classification and Prediction, Comparing classification Methods, Classification by Decision Tree Induction: Decision Trees and Decision Trees induction

Unit 5
Clustering Methods – Clustering Analysis, Types data in clustering analysis: Scaled variable, Binary variables, Variables of Mixed Types, Partitioning Methods: K-means and K-Medoids, Model-Based Methods, Data Mining Applications: Data mining for Biomedical and DNA Data Analysis

Text Books:

Reference Books:
1. Data Mining: Practical machine learning tools Techniques with java implementation by Ian H.Witten, Eibe Frank, 2005.
BINF 547 – RESEARCH METHODOLOGY AND FINISHING SCHOOL

Total Credits: 3  
Total: 36 Hrs.

Unit 1  
**Research Methodology** Objectives of research and motivation; Problem Identification & Formulation – Research Question - Hypothesis and Hypothesis Testing; Types of research - Qualitative vs Quantitative Research - Applied vs. Fundamental Research; Features of good research design; Data Collection - Data Analysis - Interpretation of results and Report writing.

Unit 2  
**Scientific writing** – Introduction - Types of scientific writings - Thesis or dissertation writing – Research paper writing; Types of publications - Open access and subscription based resources; Scientific paper writing - Choosing a journal- Instructions to authors - Structure and Style- Authorships –figures tables with legends - References and citations - Acknowledgements- Conflict of interest; Peer review mechanism and publication process; Scientometric Analyses of a paper/journal; Ethics in publishing and Plagiarism issues. Use of software for Reference Management – (Mendeley/endnote) and detection of Plagiarism (turnitin).

Unit 3  
**Oral presentation** – Planning the oral presentations and visuals- In-class discussion (Students in small groups or individually will take up the assignments or select a research project/ topic and prepare oral presentations followed by a Q&A sessions)

Unit 4  
**Poster Presentation** – Elements and Significance of poster presentations- Planning and designing a poster- Individual Poster presentation (Students select a research project/topic and prepare posters followed by a Q&A sessions)

Unit 5  
**Personality development & team building** – Recruitment process and interview techniques, Team work - Personality development - Interpersonal skills, Time and human resources management - Goal setting - planning and scheduling work, stress at work - work-life balance, Culture and cultural ethos - cultural diversity - diversity in organizations.

**Text Books:**

**References:**
BINF 581 - LAB - STRUCTURAL BIOLOGY

Total Credits: 1

1. Advanced Visualization Software and 3D representations.
2. Small Molecule Structure determination
   a) Structure Solution: SHELXS
   b) Structure Refinement: SHELXL
3. Thermal Ellipsoid Plot:
   a) ORTEP
4. Structure analysis
   a) PARST
   b) Platon
   c) Mercury
5. Protein Structure Determination:
   a) Exploration of CCP4 website
   b) Protein Model building: COOT
   c) Structure Solution: AMoRe
6. Structure Validation
   Procheck, WHATIF, VERIFY 3D
BINF 582 - LAB - MOLECULAR MODELING AND DRUG DESIGN

Total Credits: 1

Exercises

1. Molecular Visualization Softwares: Pymol and Rasmol
2. Geometry Optimization
3. Tutorial on Molecular Dynamics: Gromacs
4. Binding Site Identification
5. Structure based Drug Design:- Molecular Docking
6. Ligand based Drug Design:- QSAR
Total Credits: 1

1. Uses of Scalar and Array Variables to manipulate DNA/RNA/Protein sequence data
2. Concatenation DNA fragments, Transcribing DNA into RNA
3. Calculating the Reverse complement of a DNA strand
4. Uses of common Array Operators
5. Uses of Do-Until Loops
6. Uses of ‘substr’ function to look into the string
7. Reading a sequence data from a file and writing the results to a file
8. Opening and closing a Directory Handle, Reading a Directory and other directory manipulation functions.
9. Uses of Subroutines
10. Uses of Hashes for the genetic code: translating codons into amino acids
11. Uses of subroutine to read FASTA files
12. Translate a DNA sequence in all six reading frames
13. Uses of Regular Expressions
14. Extract annotation and sequence from GenBank file
15. Parsing GenBank annotation using arrays
16. Extract sequence chains from PDB file
17. Uses of CGI.pm Module and Passing Parameters via CGI, Debugging CGI programs
18. Installing Bioperl, Uses of Bioperl modules for sequence manipulation, accessing local database
BINF 591 - ANALYTICAL TECHNIQUES

Total Credits: 3

Unit 1
Electrophoresis – Theory and types; moving boundary electrophoresis, zone electrophoresis, paper, cellulose acetate gel electrophoresis, Native PAGE, disc PAGE, Gradient PAGE, SDS PAGE, DNA agarose gel electrophoresis, Southern, Northern, Western blotting techniques, Isoelectric focusing, finger printing, DNA sequencing, Pulsed - field Electrophoresis, Capillary Electrophoresis.

Unit 2
Chromatography – Principles, methodology and applications of chromatography using paper, thin layer, column (gel filtration, ion exchange, affinity), gas and types of HPLC.

Unit 3
Centrifugation – Principles, types and applications. Ultracentrifugation- types, optical methods used and applications of preparative and analytical ultracentrifuges.

Unit 4
Enzyme kinetics – Membrane potential, Active site, Cofactors, apo-enzymes, Enzyme specificity, Factor affecting enzyme activity, Michaelis-Menten equation, LB Plot, Determination of Km, Types of inhibition, Allosteric enzymes.

Unit 5
Various Biophysical techniques to study interactions caused by the macromolecules: Isothermal Titration Calorimetry- instrumentation. Protocol and application in the study of Protein-ligand interactions. Optical and magnetic tweezers- principle, Instrumentation and modern developments. Role of Optical tweezers in studying the molecular motors and the properties of DNA. Fluorescence Resonance Energy Transfer: Principle, Instrumentation, Protocol and application in analyzing the macromolecular interactions. Dual Polarisation Interferometry [DPI]- Principle, Instrumentation and protocol. Application of DPI in one dimensional determination of protein structures and in studying the interactions and activity of biomolecules. ORD and CD, DLS

Text Books:

Reference Books:
1. Physical Biochemistry (2nd Ed) by D. Freifelder., Freeman. 1982
BINF 592 - BIOETHICS, BIODIVERSITY AND INTELLECTUAL PROPERTY RIGHTS

Total Credits: 3

Unit 1
8 Lectures

Unit 2
8 Lectures
Biotechnology Processes and Products – Techniques used in Biotechnology, with special emphasis on molecular and recombinant DNA techniques - Cloning Strategies and Tissue culture procedures for plant cells, animal and stem cells - Transgenic plants, animals, genetically modified organisms (GMO) and GM food etc. - Large scale production of recombinant proteins, Processes for separation and purification - Medical Biotechnology: gene therapy, tissue engineering and xenotransplantations - Biotechnology Products: Health care products – Vaccines – Diagnostics - Recombinant therapeutic proteins - Agricultural : Hybrid and modified seeds - Bio-pesticides - Bio-fertilizers

Unit 3
6 Lectures
IPR – Definition - Forms of IPR Protection, WTO - Definition — Functions- International treaties for IPR Protection

Unit 4
7 Lectures
Patents – Definition - conditions for patentability - test of novelty of patents – composition of a patent - Patenting of Biotechnological discoveries

Unit 5
7 Lectures
Other forms of IPR protection – Copyright - Trademark - Designs - Importance in Indian Scenario & laws in India for IPR protection.

Text Books:
2. Intellectual Property Rights by Deborah E. Bouchoux., Delmar Cenage Learning. 2005

Reference Books:
1. The Indian Environmental Protection Act (EPA), 1986
2. Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989
3. Food Safety and Standards act (Government of India), 2006
4. Intellectual Property Rights on Biotechnology by Singh, KC, BCIL, New Delhi
BINF 593 - R LANGUAGE AND BIOCONDUCTOR

Total Credits: 3

Unit 1
Overview of the R language – Defining the R project, Obtaining R, and Generating R codes, Scripts, Text editors for R, Graphical User Interfaces (GUIs) for R, Packages.

Unit 2
R Objects and data structures – Variable classes, Vectors and matrices, Data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files, Storing data to external files, Creating and storing R workspaces.

Unit 3
Manipulating objects in R – Mathematical operations (recycling rules, propagation of names, dimensional attributes, NA handling), Basic matrix computation (element-wise multiplication, matrix multiplication, outer product, transpose, eigenvalues, eigenvectors), Textual operations, Basic graphics (high-level plotting, low-level plotting, interacting with graphics).

Unit 4
Hypothesis testing and data handling – Parametric and nonparametric tests, Chi-square test, t-tests, ANOVA, Correlation and regression, Principal component Analysis

Unit 5
Bioconductor – Introduction, Bioconductor packages, ExpressionSet Class, Data annotation, biomaRt, Applications of R in phylogenetics, microarray data analysis, next-generation sequencing (NGS) data (RNA-Seq) analysis and network analysis.

Text Books:

Reference Books:
BINF 599 - PROJECT

Total Credits: 5

The course is designed to result in the satisfactory completion and defense of the Masters dissertation.

This process includes

a) the conceptualization of the independent research that will comprise the dissertation,
b) the preparation of and satisfactory defense of the dissertation proposal,
c) the collection, analysis, and interpretation of data,
d) presentation of findings in the dissertation format, and
e) oral defense of the dissertation.

Dissertation activity must be completed within prescribed time frame for the semester.