M.Tech. Computational Biology

REGULATIONS AND SYLLABI

(Effective from 2014-2015)

Centre for Bioinformatics
SCHOOL OF LIFE SCIENCES
PONDICHERRY UNIVERSITY
PUDUCHERRY
Eligibility for M. Tech. Computational Biology **

1) Minimum of 55% of marks in Master’s degree in any relevant area of Bioinformatics/ Physics/Chemistry/ Mathematics/ Statistics/ Computer Science/ Biotechnology/ Biochemistry/ Microbiology/ Plant Biology/ Botany/ Animal Biology/ Zoology for Pondicherry University


** Network teaching programme in collaboration with Anna University, Chennai. Admission to Anna University, Chennai will also be based on the entrance exam conducted by Pondicherry University
- Students with Biology background are expected to choose “Physical Sciences for Biologist” and students with Mathematical and Physical Science background are expected to choose “Introductory Biology” as compulsory papers.
Unit I
Introduction to primary Databases: Types of Biological data- Genomic DNA, cDNA, rDNA, ESTs, GSSs; Primary Databases - Nucleotide sequence databases- GenBank, EMBL, DDBJ, Protein Sequence Databases- UniProtKB, UniProt, TrEMBL, Swiss-Prot, UniProt Archive-UniParc, UniProt Reference Clusters-UniRef, UniProt Metagenomic and Environmental Sequences-UniMES. Literature Databases-PubMed, PLoS, BioMed Central.

Unit II
Introduction to Secondary or Derived Databases- PDB, CSD, MMDB, SCOP, CATH, FSSP, CSA, KEGG ENZYME, BRENDAN; Sequence motifs Databases- Prosite, ProDom, Pfam, InterPro; Composite Databases-NRDB, Genome Databases- Viral genome database (ICTV db), Bacterial Genome database (GOLD, MBGD), Organism specific database (OMIM/OMIA, SGD, WormBase, PlasmoDB, FlyBase, TAIR), Genome Browsers (Ensembl, VEGA, NCBI map viewer, UCSC Genome Browse). Bioinformatics Database search engines:-Text-based search engines (Entrez, DBGET/LinkDB).

Unit III
File formats, sequence patterns and profiles: Sequence file formats – GenBank, FASTA, ALN/ClustalW2, PIR; Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; Sequence similarity based search engines (BLAST and FASTA); Pattern based search using MeMe and PRATT); Motif-based search using ScanProsite and eMOTIF; Structure similarity based search using VAST and DALI; Profile-based database searches using PSI-BLAST and HMMer.

Unit IV
Sequence Analysis and predictions: Nucleic acid sequence analysis- Reading frames; Codon Usage analysis; Translational and transcriptional signals, Splice site identification, Gene prediction methods and RNA fold analysis; Protein sequence analysis-Compositional analysis, Hydrophobicity profiles, Amphiphilicity detection, Moment analysis, Transmembrane prediction methods, Secondary structure prediction methods.

Unit V
BIG DATA in OMICS: Big data industry standards, Data acquisition, cleaning, distribution, and best practices, Visualization and design principles of big data infrastructures, Biological databases for big data management, High Performance Computing, grid, and cloud computing for omics sciences, Real-Time Processing of Proteomics Data Using Hadoop.

Text books
3. Introduction to Bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson Education. 1999

References
CBIO 602 FUNDAMENTALS OF BIOSTATISTICS

Total Credits: 3  
Total: 34 Hrs.

Unit I  
6 Lectures  
**Review of Basic statistical measures:** Numerical description of data, Measures of central tendency, Measuring variations in data, Standard deviation and its significance, Percentile, Quartiles, Box Plots, Correlation and Regression, Application to Biology.

Unit II  
6 Lectures  
**Probability theory:** Classical and modern definition of probability, Sample space and events, Axioms of probability, Sample space having equally likely outcomes, Conditional probability, Independent events, Bayes formula and its application to Biology, Random Variables- Types of Variables, Expected Value, Variance

Unit III  
7 Lectures  
**Discrete and Continuous Distribution:** Bernoulli and Binomial, Poisson, Geometric, Uniform, Exponential, Normal, Standard normal, Student’s t, Chi-squared, Fisher-Snedecor distribution, their importance and usage in Biology.

Unit IV  
7 Lectures  
**Sampling Distributions and Estimation:** Statistic, Distribution of sample mean, sample variance, central limit theory, Biased and unbiased estimator, Confidence interval, Population mean, Population variance.

Unit V  
8 Lectures  
**Tests of Hypotheses:** Formulation of Hypothesis Simple and Composite, Type I and Type II errors, Power of a test, Significance of a test, P-value, Testing Normal, Chi-square, t-test and F-test, Non-parametric - Mann-Whitney test, Applications to Biology.

**Text Books**

**Reference Books**
CBIO 603 DESIGN AND ANALYSIS OF ALGORITHM

Total Credits: 3  Total: 36 Hrs.

Unit 1  5 lectures

Unit 2  6 lectures
Divide and conquer: General method, applications-Binary search, Quick sort, Merge sort, Strassen’s Matrix Multiplication. Greedy method: General method, applications-Job sequencing with deadlines, 0/1 knapsack problem, Minimum cost spanning trees, Single source shortest path problem.

Unit 3  7 lectures
Dynamic Programming: General method, applications-Matrix chain multiplication, Optimal binary search trees, 0/1 knapsack problem, All pairs shortest path problem, Traveling sales person problem, Reliability design.

Unit 4  6 lectures

Unit 5  7 lectures
Backtracking and Branch and Bound: General method (Backtracking), Applications-n-queen problem, sum of subsets problem, graph coloring, Hamiltonian cycles. General method (Branch and Bound), Applications - Traveling sales person problem.

Text Books:

Reference Books:
1. Design and Analysis of algorithms, Aho, Ullman and Hopcroft, Pearson Education.
2. Introduction to the Design and Analysis of Algorithms, A.Levitin, Pearson Education.
5. Fundamentals of Sequential and Parallel Algorithms, K.A.Berman, J. L.Paul, Thomson
CBIO 604 - C++ IN COMPUTATIONAL BIOLOGY

Total Credits: 3

Unit 1
7 lectures

**C++ programming basics**: Compilation of C++ programs – Input and output statements – integer, float, and character variables – arithmetic operations and built-in library functions.

Unit 2
9 lectures

**Procedural concept – decision making, functions and structures**: Loops and decision making statements – structures and unions – arrays and strings – user defined functions.

Unit 3
7 lectures

**Pointers and file handling**: Pointer concept – pointers and arrays – pointers and functions – pointers to pointers – File handling – Reading and Writing the data from file.

Unit 4
6 lectures


Unit 5
7 lectures

**Inheritance**: Concept of inheritance – base class and derived class – overriding of member functions – abstract class – public and private inheritance – Levels of inheritance and multiple inheritance – inheritance and graphic shapes – virtual function and friend function.

Text Books:

CBIO 605 - CELL AND MOLECULAR BIOLOGY

Total Credits: 3

Total: 36 Hrs.

Unit 1  6 Lectures

Unit 2  7 Lectures

Unit 3  7 Lectures
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

Unit 4  7 Lectures

Unit 5  9 Lectures

Text Book:

Reference Books:
2. Cell and Molecular Biology by De Robertis and De Robertis. Saunders College, Philadelphia, USA. 2002
CBIO 606- METABOLISM AND IMMUNOLOGY

Total Credits: 3  Total: 36 Hrs.

**Unit 1**  
6 lectures  

**Unit 2**  
7 lectures  
Overview of metabolism, high energy compounds, oxidation-reduction reactions, the reactions of glycolysis, fermentation, control of glycolysis. The pentose phosphate pathway, glycogen breakdown and synthesis, control of glycogen metabolism, gluconeogenesis. Citric acid cycle: enzymes of the citric acid cycle, regulation of the citric acid cycle.

**Unit 3**  
8 lectures  
Protein metabolism: amino acid deamination, the urea cycle, breakdown of amino acids, amino acid biosynthesis. Fatty acid metabolism Lipid digestion, adsorption and transport, fatty acid oxidation, ketone bodies, fatty acid biosynthesis, regulation of fatty acid metabolism. Nucleic acid metabolism: Synthesis of purine ribonucleotides, synthesis of pyrimidine ribonucleotides, formation of deoxyribonucleotides. Heme biosynthesis and degradation

**Unit 4**  
8 Lectures  

**Unit 5**  
7 Lectures  
Antigen and antibody reaction/interaction: Precipitation, Haemagglutination, direct and indirect immunofluorescence, hybridoma technology for mass production. Chimeric antibodies, antibody engineering: large scale manufacture of antibodies. Vaccine development and Immunoinformatics: Recombinant vaccines, combined vaccines, polyvalent vaccines. Immunoinformatics, databases in immunology, DNA, Plant and protein based recombinant antigens as vaccines.

**Text book:**

**Reference Books:**
3. Text book of Immunology by Riott, 2006
Total Credits: 3

Unit 1: Classical Mechanics: Types of Motion:- Uniform, projectile, circular and relative motions, Newton’s Laws of Motion, Law of Gravitation, Work and energy:- work energy theorem, conservative / non-conservative forces, energy conservation, power, Linear momentum and collisions (elastic and inelastic), impulse, momentum theorem, Rigid body rotation:- angular velocity and acceleration, rotational kinetic energy, inertia, torque, dynamics of rotation, Angular Momentum:- conservation of angular momentum, translation and rotation, Statics Oscillatory motion

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 Exclusion Principle, Schrodinger equation,

Unit 3: Thermodynamics


Text Books:
2. Fundamental Principles of Physical Chemistry (Prutton, Carl F.; Maron, Samuel H.)
3. Organic Chemistry by Morrison and Boyd Sixth Edition

Reference Books:
5. Fundamentals of Physics by Resnick, Halliday and Walker. 200
7. Selected Topics in Inorganic Chemistry, Wahid U. Malik, G. D. Tuli and R.D. Madan
8. Chemistry Introducing inorganic, organic and physical chemistry, Andrew Burrows, John Holman, Andrew Parsons, Gwen Pilling, Gareth
10. Heterocyclic chemistry at a glance, John A. Joule and Keith Mills
<table>
<thead>
<tr>
<th>Unit</th>
<th>Credits</th>
<th>Lectures</th>
<th>Content</th>
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<tbody>
<tr>
<td>I</td>
<td>3</td>
<td>7</td>
<td><strong>Unit I</strong>&lt;br&gt;<strong>Diversity of Life forms</strong>: 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 - linnaeus) classification.</td>
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<tr>
<td>II</td>
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<td>7</td>
<td><strong>Unit II</strong>&lt;br&gt;<strong>Inheritance biology</strong>: Mendelian principles- Dominance, segregation, independent assortment, Codominance, incomplete dominance, genomic imprinting, linkage and crossing over; extra chromosomal inheritance, microbial genetics, human genetics-pedigree analysis, mutations, recombination, structural and numerical alterations of chromosomes.</td>
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<tr>
<td>III</td>
<td></td>
<td>7</td>
<td><strong>Unit III</strong>&lt;br&gt;<strong>Developmental Biology</strong>: Basic concepts of development, gametogenesis, fertilization and early development, morphogenesis and organogenesis in animals and plants, programmed cell death, aging and senescence.</td>
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<tr>
<td>IV</td>
<td></td>
<td>7</td>
<td><strong>Unit IV</strong>&lt;br&gt;<strong>Ecology &amp; Evolution</strong>: Habitat and niche, population growth curves, Ecosystems stability- species interactions, competition, conservation methods (both in situ and ex situ); Origin of life, theories and evidences.</td>
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<tr>
<td>V</td>
<td></td>
<td>7</td>
<td><strong>Unit V</strong>&lt;br&gt;<strong>Applied Biology</strong>: Microbial fermentation and production of micro and macro molecules, Tissue and cell culture methods for plants and animals, Transgenic animals and plants, Genomics and its application to health and agriculture, Breeding in plants and animals, Bioremediation and phytoremediation, Biosensors.</td>
</tr>
</tbody>
</table>

**Text books**


**References**

List of Experiments:

1. Microscopical identification of cells in permanent slides
2. Identification of microorganisms from soil by serial dilution
3. Blood cell differentiation by Giemsa staining
4. Preparation of Culture media and growth determination by sigmoid curve
5. Axenization by streaking and pour plate techniques
6. Estimation of Chlorophylls
7. Estimation of proteins
8. Estimation of DNA
9. Estimation of total carbohydrates by anthrone method
10. Estimation of Aminoacid by Ninhydrin Method
11. Estimation of Cholesterol by Zak’s Method
12. Estimation of Ascorbic Acid by volumetric Method
13. Stages of mitosis by staining in allium sepa.
Total Credits: 1

1. Simple C++ programs to demonstrate various decision making and loop constructs.
2. Working with matrices.
3. Demonstration of switch construct.
4. User defined functions.
5. Working with pointers.
6. String handling functions.
7. Creating and working with classes.
8. Illustration of constructors and destructors.
9. Demonstration of scope resolution operator.
10. Operator and function overloading.
11. Simple and multiple inheritance.
12. Overloading a constructor.
CBIO 621 - MATHEMATICS FOR BIOSCIENCES

Total Credits: 3

Unit 1
Reviewing Limits, Continuity and Differentiability: Limits of Functions, Continuity of Functions; Basics of Differentiation- Differentiability, Derivatives, Interpretations of Derivatives, General Rules of Differentiations

Unit 2
Integration: Review of Definite Integrals, Double (Surface) Integrals - Definition, Iterated Integrals (Fubini’s Theorem), Properties; Triple (Volume) Integrals- Definition, Properties, Geometric Interpretation of Double and Triple Integrals

Unit 3

Unit 4
Introduction to Laplace Transform: Definition, Some Elementary Functions and their Laplace Transform, Piecewise Continuity, Sufficient Conditions for Existence and Important Properties of Laplace Transform, Convolution of Laplace Transform, Inverse Laplace Transform

Unit 5
Introduction to Fourier Transform: Definition, Fourier Series, Fundamental Fourier Transform Properties, Fourier Transform Application

Text Books:
2. Introduction to Mathematics for Life Scientists, Edward Batschelet, Springer

Reference Books
CBIO 622 ALGORITHMS IN COMPUTATIONAL BIOLOGY

Total Credits: 3

Unit 1
9 lectures

Unit 2
10 lectures
Combinatorial Pattern Matching: Hash Tables, Repeat Finding, Exact Pattern Matching; Genetic Algorithm:- Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformatics.

Unit 3
9 lectures
Hidden Markov Model: Markov processes and Markov Models, Hidden Markov Models. Forward and Backward Algorithms, Most probable state path: Viterbi algorithm, Parameter Estimation for HMMs:-Baum-Welch Algorithm, EM Algorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.

Unit 4
7 Lectures

Unit 5
8 lectures
Artificial Neural Network: Historic evolution – Perceptron, characteristics of neural networks terminology, models of neuron Mc Culloch – Pitts model, Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, single layer ANN, multilayer perceptron, back propagation learning, input - hidden and output layer computation, back propagation algorithm, Applications of ANN

Text Books:
3. Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 2001

Reference Books:
CBIO 623 - JAVA AND BIOJAVA IN COMPUTATIONAL BIOLOGY

Total Credits: 3
Total: 36 Hrs.

Unit 1
7 lectures


Unit 2
9 lectures


Unit 3
7 lectures


Unit 4
6 lectures


Unit 5
7 lectures

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:

1. Java:The completer Reference. (7th Ed.) by Herbert Schildt, TMH. 2012
CBIO 624 – DRUG DISCOVERY AND IPR

Total Credits: 3

Unit 1

Introduction to Drugs: Drug nomenclature, Routes of drug administration and dosage forms, Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of drugs - Lipinski’s rule; How drugs work - Drug targets, drug-target interaction and dose-response relationships.

Unit 2


Unit 3

Preclinical Testing of New Drugs: Pharmacology - In vitro/in vivo Pharmacokinetics and Pharmacodynamics testing; Toxicology - Acute, chronic, carcinogenicity and reproductive toxicity testing; Drug formulation testing. Clinical Trial Testing of New Drugs: Phase I, Phase II and Phase III testing; Good clinical practice (GCP) guidelines - Investigators brochures, Clinical trial protocols and trial design; Ethical issues in clinical trials - How are patient rights protected?

Unit 4

Drug Regulatory Agencies: US Food & Drug Administration (US FDA) and Central Drugs Standard Control Organization (CDSCO), India. Regulatory Applications & New Drug Approval: Investigational new drug (IND) application & New drug application (NDA); Regulatory review and approval process. Regulatory Requirements for Drug Manufacturing: Current Good manufacturing practice (cGMP) and GMP manufacturing facility inspection & approval.

Unit 5


Text Books:

1. Drugs: From discovery to approval 2nd ed by Rick NG. Wiley Blackwell (2009)

Reference books:

2. Essentials of Medical Pharmacology, 6the Edition (Hardcover) by Tripathi Kd. Publisher: Jaypee Brothers (2008)
CBIO 625 – MOLECULAR EVOLUTION

Total Credits: 3
Total: 36 Hrs.

Unit 1
6 Lectures

Unit 2
8 Lectures
The concept of homology in molecular evolution. Role of transitions and transversions; chromosomal deletions and insertions in evolution. Role of repetitive DNA, transposable elements and junk DNA in evolution.

Unit 3
10 Lectures
Neutral theory (Kimura) and nearly neutral theory (Ohta) of molecular evolution (Kimura). Phylogenetic tree. Reconstruction of phylogenetic trees using distance matrix methods, the Maximum Parsimony method, Maximum likelihood and Bayesian inference. Selection at the molecular level.

Unit 4
6 Lectures
The concept of the Molecular Clock. Calibration. Limitation of molecular clock models. Human molecular clock: deducing evolutionary histories through mitochondrial DNA and Y chromosome.

Unit 5
6 Lectures
Evolution of the genome: Human Genome Project, ENCODE, Genome 10 K, Genome duplication (Ohno’s hypothesis), Gene duplication, Exon Shuffling, Concerted evolution.

Reference Books:

CBIO 626 – GENOMICS AND PROTEOMICS

Total Credits: 3  
Total: 36 Hrs.

Unit 1  
8 Lectures
Genomics and Metagenomics: Large scale genome sequencing strategies. Metagenomics, 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  
7 Lectures
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  
7 Lectures
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  
7 Lectures
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  
7 Lectures
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:
CBIO 627-STRUCTURAL BIOLOGY

Total Credits: 3 Total: 36 Hrs

Unit I 8 Lectures

Unit II 8 Lectures

Unit III 8 Lectures

Unit IV 6 Lectures
X-ray scattering: Atomic scattering factor - diffraction by a space lattice - structure factor equation - electron density and Fourier series - Fourier Transform and crystal diffraction - diffraction by real crystals - Lorentz and polarization factor - primary and secondary extinctions.

Unit V 6 Lectures

References Books:
1. Introduction to protein structure, C. Branden and J. Tooze
6. Structural Bioinformatics, Philip E. Bourne, Helge Weissig, Wiley Publication
Total Credits: 1

1) Different types of structure representation and implications – PyMol, Chimera
2) Surface calculation and implications: Hydrophobic, charge representation
3) Secondary structure prediction
4) Structure based alignment
5) Structural Blast - DALI
6) Binding pocket prediction – Castp; Glycosilation, phosphorilation sites prediction
7) Modeller – homology modeling, threading
8) Energy Minimisation
9) Validation of models – Procheck, Whatif, Verify 3d,
10) Auto dock
11) NMR structure analysis – Demo
12) Structure analysis of Chemical compounds using IR - Demo
Total Credits: 1

1. Simple java programs to demonstrate decision making, and loops.
2. Handling of arrays and working with matrices.
3. Working with Classes and objects in java.
4. Use of constructors and demonstration of overloading of constructors.
5. Demonstration of simple, multiple and multilevel inheritances.
6. Exception handling.
7. Creation of multiple threads.
8. Reading and writing files.
10. Animation and Threads.
11. Managing Simple Events and Interactivity.
12. Alignment of sequences (biojava)
CBIO 701   BIOMOLECULAR SIMULATIONS

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

Unit 5  7 Lectures
Structure Activity Relationship: Introduction to QSAR, QSPR, Various Descriptors used in QSARs, Regression Analysis, Significance and Validity of QSAR Regression Equations, Partial Least Squares (PLS) Analysis, Multi Linear Regression Analysis. Application of Genetic Algorithms, Neural Networks and Principle Components Analysis in QSAR analysis.

Text Books:

Reference:
1. Molecular Modelling for Beginners, (2nd Edition) by Alan Hinchliffe, John Wiley & Sons Ltd. 2008
3. Computational medicinal chemistry for drug discovery edited by Patrick Bultinck, Marcel Dekker Inc. 2004
CBIO 702  BIOPHYSICAL TECHNIQUES

Total Credits: 3

Total: 36 Hrs.

Unit 1  8 Lectures
Spectroscopy: Introduction to spectroscopy: basic principles, instrumentation and applications of UV-VIS absorption, infrared, Raman, fluorescence spectroscopy

Unit 2  8 Lectures
Application of Spectroscopy to macromolecules: Amino acid, Protein absorption at UV spectra, DNA absorption spectrum, Protein-DNA interaction study using UV spectra. CD and ORD introduction, linear and circular Dichroism for biological molecules, secondary structure prediction using CD. NMR application to macromolecules. Mass spectroscopy and application to macromolecules.

Unit 3  5 Lectures
Scattering from Solutions of Macromolecules: Principles of light scattering, Rayleigh scattering, scattering from particles comparable to wavelength of radiation, static light scattering, dynamic light scattering, low angle X-ray scattering

Unit 4  8 Lectures
Separation techniques: Chromatography- column chromatography, TLC, paper chromatography, adsorption chromatography, partition chromatography, Gas liquid chromatography, Ion exchange chromatography, Molecular exclusion chromatography, affinity chromatography, Hydrophobic interaction chromatography. Electrophoresis: Moving boundary electrophoresis, zone electrophoresis, low voltage electrophoresis, high voltage electrophoresis, gel electrophoresis, SDS, Iso electric focusing, continuous flow electrophoresis, capillary electrophoresis in DNA sequencing. Centrifugation, Ultra centrifugation.

Unit 5  7 Lectures

Reference Books:

5. Introduction to biological membrane, Jain RK
6. Biomembrane structure and function, Chapman D
CBIO 703  SYSTEMS BIOLOGY

Total Credits: 3  Total: 36 Hrs.

Unit-I

5 Lectures

Networks and graph theory: Basic properties of Network: Degree, average degree and degree distribution. Adjacency matrix, weighted and unweighted networks, Bipartite network, Paths and distances.

Unit-II

5 Lectures

Random Networks: Erdos-Renyi model, Small-world effect, clustering coefficient.


Unit-III

8 Lectures


Unit-IV

8 Lectures


Unit-V

10 Lectures


Text Books:


Reference Books:


## CBIO 704  NEXT GENERATION SEQUENCING

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<td>I</td>
<td>6</td>
<td>NGS Platforms: Introduction to NGS, Roche/454 FLX, Illumina/Solexa Genome Analyzer, Applied Biosystems SOLiD system, Helicos Heliscope, Pacific Biosciences/single molecule real time (SMRT) sequencing.</td>
</tr>
<tr>
<td>II</td>
<td>8</td>
<td>Genome assembly algorithms: Alignment of short-reads to reference genome using spaced seed (ELAND, SOAP), index-filtering algorithm (SeqMap), quality-score (RMAP), q-filter algorithm (SHRiMP), FM-index (Bowtie, BWA,SOAP2), suffix tree (MUMmer), Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format, Tools for conversion (SAMtools), Alignment viewers (IGV, MGAviewer).</td>
</tr>
<tr>
<td>III</td>
<td>8</td>
<td>De-novo assembly: Overlap-layout-consensus (OLC) approach (Arachne, Phusion), de Bruijn and Euler path approach (Euler, SOAPdenovo), string graph assembler (SGA), Scaffold: Supercontig, contig orientation, contig ordering, contig distancing and gap closing using SOAPdenovo, ABySS, OPERA and RACA.</td>
</tr>
<tr>
<td>IV</td>
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<td>Application of R in NGS analysis: Introduction to Bioconductor, Reading of RNA-seq data (ShortRead, Rsamtools, GenomicRanges), annotation (biomaRt, genomeIntervals), reads coverage and assign counts (IRanges, GenomicFeatures), differential expression (DESeq).</td>
</tr>
<tr>
<td>V</td>
<td>6</td>
<td>Biological applications of NGS: Whole-genome sequencing, Exome sequencing, Transcriptome sequencing, Epigenome sequencing, Interactome sequencing, methylome sequencing.</td>
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</tbody>
</table>

**Text Books:**


**Reference Books:**

CBIO 705  DATA MINING AND DATA WAREHOUSING

Total Credits: 3  Total: 36 Hrs.

Unit 1  Introduction
Need for data warehouse, definition, goals of data warehouse, Data Mart, Data warehouse architecture, extract and load process, clean and transform data, Designing fact tables, partitioning, Data warehouse and OLAP technology.

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
Architectures of Data Mining Systems, Data Mining Primitives, Data Mining Query Language, Designing Graphical User, Interfaces Based on a Data Mining Query Language

Unit 3  Concept Description and Association Rules
Concept Description, Characterization and comparison, Data Generalization and Summarization - Analytical Characterization, Mining Class Comparisons, Association Rule Mining, Mining Association Rules in Large Databases, Mining Single-Dimensional Boolean Association Rules from Transactional Databases, Mining descriptive statistical measures in large data bases, multidimensional association rules from relational DBS and DWS, Correlation analysis, Constraint based association mining.

Unit 4  Classification and Prediction
Classification and Prediction, Issues: Data preparation for classification and Prediction, Comparing classification Methods, Classification by Decision Tree Induction, Back propagation, Bayesian classification.

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, Data Mining Applications: Data mining for Biomedical and DNA Data Analysis.

Text Books:
2. Building Data Warehouse by W.H.Inmon, John Wiley & Sons
3. Data warehousing by S. Anahory and D.Murray, Pearson Education, ASIA
CBIO 706  PERL PROGRAMMING FOR BIOLOGISTS

Total Credits: 3  Total: 34 Hrs.

Unit 1  7 Lectures
**Basic Datatypes:** Scalar Variables, Scalar Operations and Functions, Array Variables, Literal Representation of Array, Array Operations and Functions, Scalar and List Context, Hash Variables, Literal Representation of a Hash, Hash Functions

Unit 2  7 Lectures
**Perl Regular Expression:** Concepts on Regular Expressions, Uses of Regular Expressions in Biology, Patterns, Matching Operator, Substitutions, Split and Join functions.

Unit 3  7 Lectures
**Modular Programming:** Subroutines, Advantage of Subroutines, Scoping and Subroutines, Arguments, Passing Data to Subroutines, Modules and Libraries of Subroutines, Concept on File handle, Opening and Closing a File Handle, Opening and Closing a Directory Handle, Reading a Directory Handle, File and Directory Manipulation.

Unit 4  7 Lectures
**Common Gateway Interface (CGI):** The CGI.pm Module, CGI program in Context, Simple CGI programs, Passing Parameters via CGI, Perl and the Web

Unit 5  8 Lectures
**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, Databases- Database Classes, Accessing a Local Database

Text Books

1. Beginning Perl for Bioinformatics (1st Ed.), J. Tisdall, O’Reilly, 2004
Total Credits: 4

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.
CBIO 751  BIMOLECULAR SIMULATIONS - LAB

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
CBIO 752  DATA MINING AND DATA WAREHOUSING -LAB

Total Credits : 1

Exercises

1 Demonstration of Data mining tools: Weka, Tanagra, Rapid miner, Keel, Orange
2 Introduction, Data pre-processing on dataset
3 Association rule process on dataset using apriori algorithm
4 classification rule process on dataset using j48 algorithm
5 classification rule process on dataset using id3 algorithm
6 classification rule process on dataset using naïve bayes algorithm
7 clustering rule process on dataset using simple k-means
8 clustering rule process on dataset using simple k-means
CBIO 721 - BIOMEDICAL INFORMATICS AND TRANSLATIONAL RESEARCH

Total Credits: 2  Total 24 hrs

Unit I
4 Lectures
Overview of Medical Informatics - Healthcare functions and information technology, Key Players in Health Information technology (HIT), Organizations involved with HIT, Barriers to HIT Adoption. Public Health Informatics - Information systems in public health - National Health Information Infrastructure (NHII). Internet based consumer health information - telehealth and telemedicine.

Unit II
6 Lectures

Unit III
4 Lectures
Managing Information Security and Privacy in Health Care Data. General approaches to assuring appropriate use of data, data tracking and deidentifying data. Methods and Evaluation in biomedical decision making: Sampling, appropriate use of controls, data collection, testing of statistical significance, sensitivity and specificity, ROC plots. Standards in Biomedical informatics; Ethics, legal and regulatory matters in health informatics.

Unit IV
4 Lectures
Clinical Decision-Support Systems - The Nature of clinical decision making, types of decisions, The role of computers in decision support, Historical perspectives- Leeds abdominal pain system, MYCIN, HELP; Illustrative examples of clinical decision-support systems- Internist-1, DXplain system. Patient monitoring system and information management in intensive care unit.

Unit V
6 Lectures
Translational Research - Concepts and Principles. Therapeutic discovery in an academic setting, Technology Transfer and Commercialization process of a product. Bringing drugs from bench to bedside for cancer therapy - Molecular basis of cancer, strategies for developing therapeutic treatments, how imatinib and dasatinib were developed. Principles of Clinical Trials: Genetics/Omics in Clinical Investigation, Principles of biomarker development and utility, pharmacogenomics including utilization of key knowledge from the human genome projects for personalized medicine. Regulatory and ethical issues involved in translational clinical research.

Text Books:

Reference Books:
## CBIO 722 – GENETIC ENGINEERING-(rDNA Technology)

Total Credits: 3

Total 36 hrs

### UNIT I
**7 Lectures**
Scope of Genetic Engineering, Milestones in Genetic Engineering, Genetic engineering guidelines, Regulatory Procedures: Good laboratory practice, Good manufacturing practice and FDA regulations - Regulations for recombinant DNA research and manufacturing process - Bio-safety and Bioethics - Regulations for clinical trials, Documentation and Compliance, in India and selected countries.

### UNIT II
**8 Lectures**
Nucleic Acid cloning and amplification methods: Molecular Tools in genetic engineering: Restriction enzymes, Restriction Mapping of DNA Fragments and Map Construction. Ligases, S1 nuclease, terminal deoxynucleotides, transferases, polymerases, Reverse Transcriptase and Alkaline phosphatase. Gene Cloning Vectors- Plasmids, bacteriophages, phagemids, cosmids, artificial chromosomes. Ligation – transformation methods, Polymerase chain reaction, Primers, Gene amplification and applications, Real Time PCR, Microarray techniques, DNA Sequencing methods; Enzymatic sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing.

### UNIT III
**8 Lectures**

### UNIT IV
**6 Lectures**

### UNIT V
**7 Lectures**

### BOOKS
**CBIO 723 PROJECT**

**Total Credits: 8**

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

This process includes

f) the conceptualization of the independent research that will comprise the dissertation,

g) the preparation of and satisfactory defense of the dissertation proposal,

h) the collection, analysis, and interpretation of data,

i) presentation of findings in the dissertation format, and

j) oral defense of the dissertation.

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