# M. Tech. Computational Biology

## REGULATIONS AND SYLLABI

**(Effective from 2017-2018)**

## 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 Bioinformatics/computational biology/Physics/Chemistry/ Mathematics/ Statistics/ Computer Science/ all branches in Life sciences (Biotechnology/ Biochemistry/ Microbiology/ Plant Biology/ Botany/ Animal Biology/ Zoology) for Pondicherry University

2) Minimum of 55% of marks in B.Tech /B.E degree in Industrial Biotechnology, Biotechnology, Pharmaceutical Technology, Food Technology, Bioinformatics, Chemical Engineering, Leather, Bioengineering, Information Technology, Information Science, Computer Science and Engineering, Electrical and Electronics Engineering, Electronics and Communication Engineering, Mechanical Engineering, Biomedical Engineering, Electronics and Instrumentation Engineering for both Anna University and 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

# PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCES

## CENTRE FOR BIOINFORMATICS

## SYLLABUS FOR M. Tech. Computational Biology

(Academic Year 2017-2018 onwards)

| Course Code | Course Title | H/S | Credits | Pg. No. |
|---|---|---|---|---|
| **Semester I** | | | | |
| CBIO 611 | Bioinformatics and Sequence Analysis | H | 3 | 6 |
| CBIO 612 | Fundamentals of Biostatistics | H | 3 | 8 |
| CBIO 613 | Design and Analysis of Algorithm | H | 3 | 9 |
| CBIO 614 | Programming in C++ | H | 3 | 10 |
| CBIO-615 | Basics of Cell and Molecular Biology | H | 3 | 11 |
| | **Lab** | | | |
| CBIO 651 | Cell and Molecular Biology | H | 1 | 15 |
| CBIO 652 | Programming in C++ | H | 1 | 16 |
| CBIO-653 | Bioinformatics And Sequence Analysis | H | 1 | 17 |
| | **Total Credits** | | **18** | |
| **Semester II** | | | | |
| CBIO 621 | Algorithms in Computational Biology | H | 3 | 19 |
| CBIO 622 | Programming in Java and Biojava | H | 3 | 20 |
| CBIO 623 | Drug Discovery and IPR | H | 3 | 21 |
| CBIO 624 | Genomics and Proteomics | H | 3 | 23 |
| CBIO 625 | Structural Biology | H | 3 | 24 |
| | **Lab** | | | |
| CBIO 654 | Structural Biology | H | 1 | 28 |
| CBIO 655 | Programming in Java and Biojava | H | 1 | 29 |
| | **Total Credits** | | **17** | |
| **Semester III** | | | | |
| CBIO 711 | Biomolecular Simulations[$] | H | 3 | 31 |
| CBIO 712 | Systems Biology | H | 3 | 32 |
| CBIO 713 | Data Mining and Data Warehousing | H | 3 | 33 |
| CBIO 714 | Metabolism and Immunology | H | 3 | 34 |
| CBIO 751 | **Project** (Phase – I) | H | 1 | 37 |
| | **Lab** | | | |
| CBIO 752 | Biomolecular Simulations | H | 1 | 38 |
| CBIO 753 | Data Mining and Data Warehousing | H | 1 | 39 |
| | **Total Credits** | | **15** | |
| **Semester IV** | | | | |
| CBIO 721 | Genetic Engineering (rDNA Technology) | H | 3 | 42 |
| CBIO 755 | **Project** (Phase – II) | H | 6 | 44 |
| | **Total Credits** | | **9** | |

# CBIO-607 and CBIO-621 are prerequisite for [$]CBIO-701. Students with Mathematical and Physical Science background are expected to choose CBIO-608 as compulsory papers.

*30 Hrs for 2 Credit paper (24 Lectures + 6 Tutorials)
*45 Hrs for 3 Credit paper (36 Lectures + 9 Tutorials)
*60 Hrs for 4 Credit paper (48 Lectures + 12 Tutorials)

**PONDICHERRY UNIVERSITY**

SCHOOL OF LIFE SCIENCES

**Centre for Bioinformatics**

**List of Soft-Core Courses for M. Tech. Computational Biology**

| Course Code | Course Title | S | Credits | Pg. No |
|---|---|---|---|---|
| **Semester I** | | | | |
| CBIO 616 | Physical Sciences for Biologist # | S | 3 | 12 |
| CBIO 617 | Introductory Biology * | S | 2 | 14 |
| **Semester II** | | | | |
| CBIO 626 | Biomolecular Evolution | S | 2 | 25 |
| CBIO 627 | Mathematics for Biosciences # | S | 3 | 26 |
| CBIO -628 | Big Data Analytics | S | 2 | 27 |
| **Semester III** | | | | |
| CBIO 715 | Biophysical Techniques | S | 2 | 35 |
| CBIO 716 | Perl Programming for Biologists | S | 2 | 36 |
| **Lab** | | | | |
| CBIO-754 | Perl Programming for Biologists | S | 1 | 40 |
| **Semester IV** | | | | |
| CBIO 722 | Biomedical Informatics and Translational Research | S | 2 | 44 |
| CBIO 723 | Next Generation Sequencing | S | 2 | 45 |
| CBIO-724 | Research Methodology and Finishing School | S | 2 | 46 |

# CBIO-616 and CBIO-627 are prerequisite for $ CBIO-711.

*Students with Mathematical and Physical Science background are expected to choose CBIO-617 as compulsory papers.

- 30 Hrs for 2 Credit paper (24 Lectures + 6 Tutorials)
- 45 Hrs for 3 Credit paper (36 Lectures + 9 Tutorials)
- 60 Hrs for 4 Credit paper (48 Lectures + 12 Tutorials)

# Semester I

## CBIO 611- BIOINFORMATICS AND SEQUENCE ANALYSIS

**Total Credits: 3** **Total: 45 Hrs.***

**Unit I** **7 Lectures**

**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** **7 Lectures**

**Introduction to Secondary or Derived Databases**- PDB, CSD, MMDB, SCOP, CATH, FSSP, CSA, KEGG ENZYME, BRENDA; 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** **7 Lectures**

**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; Profile-based database searches using PSI-BLAST and HMMer.

**Unit IV** **7 Lectures**

**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** **7 Lectures**

**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. **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).

**Text books**


1. Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
2. Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009
3. Introduction to Bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson

Education. 1999

## References


1. Near real-time processing of proteomics data using HADOOP by Hillman et al., (2014) Mary ann Liebert, Inc- Big Data. 2 (1): BD44- BD49.
2. Curating Big Data Made Simple: Perspectives from Scientific Communities by SoweSulayman K. and ZettsuKoji **(2014).** Big Data. 2 (1): 23-33
3. The quantified self: Fundamental Disruption in Big Data Science and Biological Discovery by Melanie Swan (2013) Mary ann Liebert, Inc. Big data , 1(2): BD85-99.

## CBIO 612- FUNDAMENTALS OF BIOSTATISTICS

**Total Credits: 3** **Total: 45 Hrs.***

**Unit I** **8 Lectures**

**Review of Basic statistical measures**: Numerical description of data, Measures of central tendency, Measuring variations in data, Standard deviation and its significance, Percentiles, Quartiles, Box Plots. Correlation and regression, and their applications in biological data analysis.

**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** **6 Lectures**

**Discrete and Continuous Distribution**: Binomial distribution, Poisson distribution, Poisson approximation to Binomial distribution, Hypergeometric distribution, Joint distribution of two variables, Normal and Standard normal distribution, Normal approximation to Binomial (Poisson).

**Unit IV** **8 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 test.

**Text Books**

1. Biostatistics (9th Ed.), Wayne W. Daniel, John Wiley, 2004
2. Probability and Statistics ($5^{th}$ Ed.), J.L. Devore, Thomson Asia, 2002
3. Statistics ($3^{rd}$ Ed.), Murray R. Spiegel and Larry J. Stephens, Tata McGraw-Hill, 2000

**Reference Books**

1. Statistical Methods (Volume 1 and 2) ($1^{st}$ Ed.), N. G. Das, Tata McGraw-Hill, 2009
2. Fundamentals of Biostatistics (6th Ed.), Bernard Rosner, Thomson Brooks/Cole, 2006

## CBIO 613 - DESIGN AND ANALYSIS OF ALGORITHM

**Total Credits: 3** **Total: 45 Hrs***

**Unit 1** **7 lectures**

**Algorithm Analysis:** Analyzing algorithms-Designing algorithms-Asymptotic notation-Standard notations and common functions-The substitution method-The recursion tree method-The master method -Basics of time complexity estimates, General norms for running time calculation

**Unit 2** **7 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** **8 lectures**

Searching and Traversal Techniques: Efficient non-recursive Tree Traversal Algorithms, DFS, BFS of Graphs, AND/OR graphs, game trees, Bi-Connected components, Search Trees- Balanced search trees-AVL trees, representation, Operations-insertion, deletion and searching,
B-Trees-B-Tree of order m, Operations- insertion, deletion and searching.

**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:**


1. Computer Algorithms/C++, E.Horowitz, S.Sahani and S.Rajasekharan, Galgotia Publishers pvt. Limited.
2. Data Structures and Algorithm Analysis in C++, 2nd Edition, Mark Allen Weiss, Pearson Education.
3. Introduction to Algorithms, 2nd Edition, T.H.Cormen, C.E.Leiserson, R.L.Rivest, and C.Stein, PHI Pvt.Ltd./ Pearson Education.


**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.
3. Data structures, Algorithms and Applications in C++, S.Sahni, University press (India) pvt ltd, 2nd edition, Orient Longman pvt.ltd.
4. Object Oriented Programming Using C++, 2nd Edition, I.Pohl, Pearson Education.
5. Fundamentals of Sequential and Parallel Algorithms, K.A.Berman, J. L.Paul, Thomson
6. Data Structures And Algorithms in C++, 3rd Edition, Adam Drozdek, Thomson.
7. Algorithm Design: Foundations, Analysis and Internet examples, M.T.Goodrich and R.Tomassia, John Wiley and sons.

## CBIO 614 - PROGRAMMING IN C++

**Total Credits: 3** **Total: 45 Hrs*.**

**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**

**Object Oriented Programming:** Object oriented concepts – working with objects and classes in C++ – scope resolution operator – constructors – destructors – overloading of constructors and operators – string class.

**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:**

1. Object Oriented Programming using C++ ($4^{th}$ Ed.) by Lafore, R. Sams Publishers. 2002

## CBIO 615 -BASICS OF CELL AND MOLECULAR BIOLOGY

**Total Credits: 3** **Total: 45 Hrs.***

**Unit 1** **9 Lectures**

**Structural organization of cells:** cell theories, prokaryotic and eukaryotic cells and biomolecular composition of cells. Biomembranes- Models of a plasma membrane, Membrane properties, Transport across cell membranes, signal transduction mechanisms (GPCRs, tyrosine kinases, acetylcholinesterase. Artificial membrane (liposomes)

**Unit 2** **9 Lectures**

**Mitochondria structure and function:** ultra-structure, origin and replication, Functions- cellular respiration (Glycolysis, oxidation of pyruvic acid, Fate of pyruvate under aerobic and anaerobic conditions, TCA cycle and energy conversion- Electron transport and oxidative phosphorylation (Translocation of Protons and the Establishment of a proton-motive force; machinery for ATP formation (Chemiosmotic theory). Regulation and dysfunctions of mitochondrial intermediary products

**Unit 3** **9 Lectures**

**Chloroplast structure and function**: An overview of photosynthetic Metabolism, Absorption of light, Photosynthetic units and reaction centers, Photo-phosphorylation, Carbon-dioxide fixation

**Unit 4** **9 Lectures**

**Cellular Components and their functions:** Peroxisomes, Lysosomes, Cytoskeleton – components of Cytoskeleton, Microtubules, Intermediate filaments, Microfilaments. Endoplasmic reticulum, Golgi complex, Types of vesicles. Cell cycle and regulation.

**Unit 5** **9 Lectures**

**DNA and Protein Synthesis:** Structure of DNA, Experimental evidence to prove DNA as genetic material. Mechanism of DNA replication, transcription and translation in both prokaryotes and eukaryotes. Protein synthesis – Ribosomes, enzymes, Protein processing.

**Text Book:**


1. Cell and Molecular Biology – Concepts and Experiments by Gerald Karp. Wiley International Student Version. 2008
2. Cell and Molecular Biology by De Robertis and De Robertis. Saunders College, Philadelphia, USA. 2002
3. Molecular Biology of the cell (4 th Ed.) by Bruce Alberts. Garland publishing Inc. 2002


**Reference Books:**


1. Genes VIII (8 th Ed.) by Lewin, B. Pearson Education International. 2004.
2. Concepts of Biology ($2^{nd}$ Ed.) by Sylvia S. Mader. McGraw Hill Publishers, 2011
3. Principles of Gene Manipulation- An Introduction to Genetic Engineering By S.B. Primrose, university of California Press

## CBIO 616- PHYSICAL SCIENCES FOR BIOLOGIST

**Total Credits: 3** **Total: 45 Hrs***

**Unit 1:** **8 Lectures**

**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** **6 Lectures**

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** **8 Lectures**

Continuum Model, System (closed, isolated), State functions & variables, Adiabatic & diathermal boundary walls, Equilibrium, Process, equation of state. Heat, Zeroth Law of Thermodynamics, Heat Conduction Equation, The First Law of Thermodynamics, Work, Entropy, The Second Law of Thermodynamics:- reversibility and irreversibility, free and isothermal expansions, Heat Capacity, Isothermal and reversible-adiabatic expansion of an Ideal Gas , Enthalpy, Change of state, Latent heat and Enthalpy, Carnot cycle, Gibbs and Helmholtz free energy, Young's Modulus, The Third Law of Thermodynamics.

**Unit4** **6 Lectures**

**Introduction to inorganic chemistry:** Atomic Structure - Elements and compounds, atoms and molecules-definition, Classical atomic models - J. J. Thomson, E. Rutherford, N. Bohr. Electronic configuration - aufbau principle - Pauli exclusion principle - Hund's rule- Modern periodic table, periodicity. Chemical bonds - ionic bonding - covalent bonding - Coordinate covalent bonding. Overlap of σ and π orbitals – hybridization, resonance, Bond properties, Molecular geometry.

**Unit5** **8 Lectures**

**Introduction to Organic chemistry:** Carbon and its compounds, Position of Carbon in periodic table, tetra covalency of carbon, functional groups. **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. **Heteroaromatics:** Five / six membered hetero aromatics and analogues, Nucleic acid bases, Structure, electron rich electron deficient heterocycles.

**Text Books:**


1. Physics for Scientists and Engineers (6th Ed.) by Raymond A. Serway, John W. Jewett, Thomson Brooks/Cole. 2004
2. Fundamental Principles of Physical Chemistry (Prutton, Carl F.; Maron, Samuel H.)
3. Organic Chemistry by Morrison and Boyd Sixth Edition


**Reference Books:**


4. Physics for Scientists and Engineers by Paul A. Tipler, Gene P. Mosca. Freeman Company. 2007

5. Fundamentals of Physics by Resnick, Halliday and Walker. 200
6. *Chemistry, The Central Science*, 10th edition, Theodore L. Brown; H. Eugene LeMay, Jr.; and Bruce E. Bursten
7. Selected Topics in Inorganic Chemistry, Wahid U. Malik, G. D. Tuli and R.D. Madan
8. Chemistry$^3$ Introducing inorganic, organic and physical chemistry, Andrew Burrows, John Holman, Andrew Parsons, Gwen Pilling, Gareth
9. Organic Chemistry by Paula Yurkanis Bruice, Prentice Hall. 2010
10. Heterocyclic chemistry at a glance, John A. Joule and Keith Mills

## CBIO 617 - INTRODUCTORY BIOLOGY

**Total Credits: 2** **Total: 30 Hrs.***

**Unit I** **5 Lectures**

**Diversity of Life forms:** 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.

**Unit II** **5 Lectures**

**Inheritance biology:** Mendelian principles- Dominance, segregation, independent assortment, Codominance, incomplete dominance, genomic imprinting, linkage and crossing over; extra chromosomal inheritance, microbial genetics, mutations, recombination, structural and numerical alterations of chromosomes.

**Unit III** **4 Lectures**

**Developmental Biology:** Basic concepts of development, gametogenesis, fertilization and early development, morphogenesis and organogenesis in animals and plants, programmed cell death, aging and senescence.

**Unit IV** **4 Lectures**

**Ecology & Evolution:** 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.

**Unit V** **6 Lectures**

**Applied Biology:** 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, Bioremediation and phytoremediation.

**Text books**


1. Concepts of Biology (2nd Ed.) by Sylvia S. Mader. McGraw Hill Publishers, 2011.
2. Molecular Biology of the cell (4 th Ed.) by Bruce Alberts. Garland publishing Inc. 2002


**References**


1. Fundamentals of Ecology Eugene P.*ODUM* 1971 (Third Edition): W. B. Saunders, Comp. Philadelphia – London – Toronto.
2. Developmental biology by Scott F Gilbert 9th edition.
3. Principles of Gene Manipulation- An Introduction to Genetic Engineering By S.B. Primrose, university of California Press

## CBIO 651-CELL AND MOLECULAR BIOLOGY – LAB

Credit: 1

List of Experiments:

1. Karyotyping and visualization of mitotic stages by staining in allium sepa.
2. Blood cell staining by Giemsa method.
3. Isolation of bacteria from soil by serial dilution and pure culture maintenance
4. Colony counting and Culture growth determination by sigmoid curve
5. Extraction, quantitation and profile of genomic and plasmid DNA.
6. Restriction digestion and ligation for specific DNA
7. Amplification of that DNA fragments through PCR
8. Protein profiling through SDS PAGE
9. Estimation of Chlorophylls and pigment profiling through paper chromatography
10. Estimation of proteins by Bradford and Lowry methods

## CBIO 652 – PROGRAMMING IN C++ - LAB

**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 653- LAB BIOINFORMATICS AND SEQUENCE ANALYSIS

**Total Credits: 1**

**Exercices:**

1. Sequence Databases: EMBOSS, NCBI ToolKit, Expassy tools

2. Search tools against Databases:
    i. BLAST
    ii. FASTA

3. Pair wise alignment:
    a. Dot Plot
    b. Global and Local alignment methods

4. Multiple sequence alignment:
    a. Clustal
    b. Dialign
    c. Multalign

5. Primary and secondary structure prediction methods
    a. GOR Method
    b. PSI-pred
    c. Chou-Fasman method

6. 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

7. Protein motif and domain analysis:
    a. MEME/MAST
    b. eMotif
    c. InterproScan
    d. ProSite
    e. ProDom
    f. Pfam

8. Tools in sequence assembly and annotation

# Semester II

## CBIO 621 - ALGORITHMS IN COMPUTATIONAL BIOLOGY

**Total Credits: 3** **Total: 45 Hrs*.**

**Unit 1** **6 lectures**

**Algorithms in Computing:** Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms, Laplace's Rule. **Search Algorithms:** Random walk, Hill climbing, simulated annealing

**Unit 2** **7 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** **7 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, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.

**Unit 4** **8 Lectures**

**Support Vector Machines:** Introduction, hyperplane separation (maximum and soft margin hyperplanes), linear classifier, Kernel functions, Large Margin Classification, Optimization problem with SVM, Applications of SVM in bioinformatics. **Bayesian network**: Bayes Theorem, Inference and learning of Bayesian network, BN and Other Probabilistic Models.

**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:**

1. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press.2004
2. Biological sequence analysis: Probabilistic models of proteins and nucleic acids by Richard Durbin, Eddy, Anders Krogh, 1998
3. Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 2001
4. Neural Networks: A Systematic Introduction by Raul Rojas. Springer. 1996

**Reference Books:**

1. Bioinformatics: the machine learning approach by Pierre Baldi, Søren Brunak. MIT Press.2001
2. Bioinformatics: Sequence and Genome Analysis: by David Mount, University of Arizona,Tucson

## CBIO 622 - PROGRAMMING IN JAVA AND BIOJAVA

**Total Credits: 3** **Total: 45 Hrs*.**

**Unit 1** **7 lectures**

**Introduction to Java:** Compilation of java programs – Java Development kit – virtual machine – byte code – data types (int, long, char, and Boolean) – operators (arithmetic, relational, bitwise and assignment) – arrays – operator precedence – type conversion – control statements and loops.

**Unit 2** **9 lectures**

**Working with java classes:** Declaring classes – super and sub classes – constructors – instances of classes – inheritance (simple, multiple and multilevel) – overriding and overloading – exception handling – file handling.

**Unit 3** **7 lectures**

**Multi-thread programming:** Life cycle of a thread – creating a thread (extension of thread class and implementing runnable) – thread priorities – synchronization – deadlock.

**Unit 4** **6 lectures**

**Event handling and applets:** Event handling mechanisms – delegation event model – event classes – event listener interfaces – mouse and keyboard events – adapter classes and inner classes. Applet basics – passing parameters to applets – applet display methods – drawing lines, ovals, rectangles and polygons – threads and animation.

**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 (Point Location, Range Location, 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. ($7^{th}$ Ed.) by Herbert Schildt, TMH. 2012

## CBIO 623 – DRUG DISCOVERY AND IPR

**Total Credits: 3** **Total: 45 Hrs***

**Unit 1** **8 Lectures**

**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** **6 Lectures**

**New Drug Discovery & Development:** Overview of new drug discovery, development, cost and time lines. **Target Identification & Validation**. **Lead Discovery**: Rational and irrational approaches - Drug repurposing, Natural products, High-throughput screening (HTS), Combinatorial chemistry and computer aided drug design (CADD).

**Unit 3** **6 Lectures**

**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** **6 Lectures**

**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** **10 Lectures**

**Intellectual Property Rights (IPR):** IPR Definition and implications for discovery & development. Forms of IPR Protection - Copyright, Trademark and Patents. International organization and treaties for IPR protection – World Trade Organization (WTO) & Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreements. Importance of IPR in Indian Scenario & Indian laws for IPR protection. **Patents**: National and international agencies for patenting - US Patent & Trademark office (USPTO), Controller General of Patents, Designs & Trade Marks, India (CGPDTM), World Intellectual Property organization (WIPO)-Patent Cooperation Treaty (PCT); Requirements for patentability, Composition of a patent, How to apply and get patents – US, Indian and PCT.

**Text Books:**


1. **Drugs: From discovery to approval** 2nd Ed by Rick NG. Wiley Blackwell (2009)
2. **Intellectual Property Rights** by Deborah E. Bouchoux,. Delmar Cenage Learning. 2005

**Reference books:**


1. **Burger's Medicinal Chemistry and Drug discovery**. Volume 2, Drug Discovery and development.6th Edition. Ed Donald J Abraham Wiley- Interscience.
2. **Essentials of Medical Pharmacology**, 6the Edition (Hardcover) by Tripathi Kd. Publisher: Jaypee Brothers (2008)
3. **Laws of Patents: Concepts and Cases** Edited by A. V. Narasimha Rao © 2005 The ICFAI University Press
4. **Intellectual Property Rights In India: General Issues And Implications** by Prankrishna Pal. Publisher: Deep & Deep Publications Pvt.Ltd (2008)

## CBIO 624 – GENOMICS AND PROTEOMICS

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

**Unit 1** **8 Lectures**

Genomics: Large scale genome sequencing strategies. 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, Metagenomics.

**Unit 2** **7 Lectures**

Transcriptome Analysis: Databases 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), RNA Sequencing

**Unit 3** **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 4** **7 Lectures**

**Evolution from protein chemistry to proteomics:** The proteomics workflow - Basic of separation sciences: Protein and peptides; Two-dimensional electrophoresis (2-DE), Advancement in solubilization of hydrophobic proteins, development of immobilized pH gradient strips, gel casting, staining of gels and image analysis. Two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Blue native PAGE (BN-PAGE), gel free proteomics methods.

**Unit 5** **7 Lectures**

**Quantitative Proteomics:** Protein MS applications – identifying unknown proteins by peptide mass fingerprinting; de novo sequencing of peptides from fragment ion spectra obtained by tandem MS; Protein arrays: basic principles. Bioinformatics tools for proteomics (SEQUEST, MASCOT etc.)

**Text Books:**

1. Discovering Genomics, Proteomics and Bioinformatics 2nd edition - by A. Malcolm Campbell and Laurie J. Heyer. by Cold Spring Harbor Laboratory Press 2006.

**Reference books:**

1. Principles of Genome Analysis and Genomics (3rd Ed.) by Primrose, S.B. and Twyman, R.M., Blackwell Publishing Company, Oxford, UK. 2003
2. Introduction to Proteomics – Tools for the new biology (1st Ed.) by Liebler, D.C., Humana Press Inc., New Jersey, USA. 2002
3. Bioinformatics and Functional Genomics by Pevsner, J., John Wiley and Sons, New Jersey, USA. 2003
4. Bioinformatics: Sequence and Genome Analysis by Mount, D., Cold Spring Harbor Laboratory Press, New York. 2004

## CBIO 625-STRUCTURAL BIOLOGY

**Total Credits: 3** **Total: 45 Hrs***

**Unit I** **10 Lectures**

**Fundamentals of protein structure**- amino acids fundamental building blocks, Peptide bond, rigid planar peptide unit, *cis* and *trans* configuration. **Structural Hierarchy**: Primary, Secondary, Tertiary, Quaternary structures. **Motifs and domains**: α - domain structures, β - domain structures, α /β (alpha/beta) - structures. **Principles of nucleic acid structure:** Chemical structure of nucleic acids, Watson and Crick's base-pairings and their implications. Non Watson and Crick pairing schemes - base stacking interactions - DNA polymorphism - structure of ADNA, BDNA and ZDNA - helical transitions.

**Unit II** **6 Lectures**

**Protein Crystallization**: Principles of protein crystallization, Preparation of crystal for X-ray experiment. **Crystallization techniques**: Batch method, liquid-liquid diffusion method, vapour diffusion method- hanging drop, sitting drop, dialysis. **Seeding Method**-macroseeding, microseeding, other seeding methods

**Unit III** **8 Lectures**

**Elementary crystallography: Introduction**: symmetry in crystals, lattices and unit cells, crystal systems, Bravais lattices, **Elements of symmetry** - rotation axis, mirror planes and center of inversion, proper/ improper axes of rotation, translational symmetry- screw axis and glide planes. **Symmetry operation:** classes of symmetry operations, classification of symmetry point groups and molecular space groups and equivalent points. X-ray diffraction - Laue equations - Bragg's law - reciprocal lattice and its application to geometrical Crystallography.

**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 - **Phase Problem** – Direct methods, molecular replacement method, Patterson function, heavy atom method.

**Unit V** **6 Lectures**

**Nuclear Magnetic Resonance**:- Introduction, Nuclear spin, NMR sensitivity, shielding and deshielding effects of NMR, nuclear Over hauser effect. Spectral parameters: chemical shift, spin-spin splitting, coupling, non-equivalent proton. Carbon-13 NMR spectra of protein, FTNMR, spin-spin splitting, proton spin decoupling, off-resonance decoupling, Spin-lattice relaxation time. Multidimensional NMR, COSY, NOSEY, MRI, ESR. Application of NMR to biology- Regulation of DNA transcription, Protein-DNA interaction.

**Text Books:**


1. Introduction to protein structure, C. Branden and J. Tooze
2. X-Ray Structure Determination: A Practical Guide, 2nd Edition, by George H. Stout , Lyle H. Jensen.
3. Principles of Protein Structure by G. E. Schulz., Springer 2009


**References Books:**


1. Structural Bioinformatics, Philip E. Bourne, Helge Weissig, Wiley Publication
2. Crystallization of Biological Macromolecules, A. McPherson, Cold Spring Harbor Laboratory Press

## CBIO 626 – BIOMOLECULAR EVOLUTION

**Total Credits: 2** **Total: 30 Hrs*.**

**Unit 1** **5 Lectures**

History of evolution of life on earth: Chemical basis of evolution, Evolution of DNA, RNA and proteins, origin of the genetic code. Hardy-Weinberg equilibrium; Evolutionary changes by mutation al impact gene flow, genetic drift. .

**Unit 2** **5 Lectures**

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

**Unit 3** **6 Lectures**

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

**Unit 4** **4 Lectures**

The concept of the Molecular Clock. Calibration. Limitation of molecular clock models. Human molecular clock: deducing evolutionary histories through mitrochondrial 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. Evolutionary Medicine.

**Text Books:**


1) An Introduction to Molecular Evolution and Phylogenetics by Lindell Bromham, 2016, Oxford University Press.
2) Molecular Evolution by Wen Hsiung-Li, 1997, Sinauer Associates, Sunderland, MA


**Reference Books:**


1) Evolution (3rd Edition) by Ridley, M., 2004, Wiley.
2) Principles of Evolutionary Medicine by Gluckman, P. et al. 2009, Oxford University Press.

## CBIO 627 - MATHEMATICS FOR BIOSCIENCES

**Total Credits: 3** **Total: 45 Hrs.***

**Unit 1** **8 Lectures**

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

**Unit 2** **7 Lectures**

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** **7 Lectures**

Differential Equation: Ordinary Differential Equation (ODE)- Definition, Equations of First order and degree- Homogeneous and Non-homogeneous Equations, Exact Differential Equations, Condition, Rules of Finding Solution, Partial Differential Equation (PDE)- Definition, Derivation of a PDE, PDE of First Order, Linear PDE

**Unit 4** **7 Lectures**

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** **7 Lectures**

Introduction to Fourier Transform: Definition, Fourier Series, Fundamental Fourier Transform Properties, Fourier Transform Application Convolution.

**Text Books:**

1. Fundamentals of University Mathematics (3rd Ed.), Colin McGregor, Woodhead Publishing in Mathematics, 2010
2. Introduction to Mathematics for Life Scientists, Edward Batschelet, Springer

**Reference Books :**

1. Higher Engineering Mathematics (40th Ed), B.S. Grewal and J.S. Grewal, Khanna Publishers, 2007

## CBIO 628- BIG DATA ANALYTICS

**Total Credits: 2** **Total: 30 Hrs*.**

**UNIT 1** **4 lectures**

**Fundamentals of Big Data-** Overview of Big Data: history of big data, Concepts and terminology, Big Data Skills and Sources of Big Data, elements, advantages, disadvantages

**Unit II** **4lectures**

**Understanding of Big Data-**Characteristics of Big Data - Four V's, Basic operations of in big data, Datasets , Data analysis, Data Analytics, different data types of big data, Awareness of Architecture .

**UNIT III** **6 lectures**

**Big Data Analysis-** Big data storage concepts: Source, Difference of Big data from other source, Data Generation points, Big Data processing concepts, Sorting, selection of data, Storage Technology, Big data analytics, Big Data Analysis techniques: Big Data Analytics Lifecycle

**UNIT IV** **6 lectures**

**The Big Data Technology-** Key aspects, Types of tools used in Big data, Platform, Querying big data with Hive- Introduction to the SQL Language Technologies to handle Big Data: Introduction to Hadoop, functioning of Hadoop, Cloud computing (features, advantages, applications).

**Unit V** **6 lectures**

**Big Data Adoption and Planning-** Organization Prerequisites, Data Procurement, Privacy, Security, Provenance, Limited Realtime Support, Distinct Performance Challenges, Distinct Governance, Requirements, Distinct Methodology, Clouds, Application of Big Data, Five High Value Big Data Use Cases

**Text Books**

1. Big Data Fundamentals, Concepts, Drivers & TechniquesCConcepts, Drivers & Techniques by Thomas Erl, Wajid Khattak, and Paul Buhler, PRENTICE HALL, 2012.
2. Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series) – Bart Baysen, 2014

**Reference Books:**

**1. Big Data Now ,** O'Reilly Radar, O'Reilly Media, 2012
**2. Big Data For Dummies**, Wiley, Judith Hurwitz, Alan Nugent, Fern Halper, Marcia Kaufman, 2012

**CBIO 654 – STRUCTURAL BIOLOGY – LAB**

**Total Credits: 1**

1. Learning the protein folding problem
    1. Denature and re-nature the protein – chromatography
    2. UV study of denatured and renatured proteins
    3. IR study of amide bond stretching
2. Secondary structure analysis :
    1. u insilico tools
    2. CD study of protein
3. Torsion angle calculation. Model the protein from given torsion angle
4. DNA melting point and intercalation study
5. Purification of protein from tissue or milk
6. Crystallization of lysozyme
7. Structure solution using molecular replacement – CCP4 suit
8. Structure based alignment and structural Blast – VAST, DALI
9. Exploration of PDB tools.

## CBIO 655- PROGRAMMING IN JAVA AND BIOJAVA -LAB

**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.
9. Applets.
10. Animation and Threads.
11. Managing Simple Events and Interactivity.
12. Alignment of sequences (biojava)

# Semester III

## CBIO 711-BIOMOLECULAR SIMULATIONS

**Total Credits: 3** **Total: 45Hrs*.**

**Unit 1** **8 Lectures**

**Molecular Mechanics**: Introduction, The Morse Potential, The Harmonic Oscillator Model for Molecules, Comparison of Morse and Harmonic Potential, Two atoms connected by a bond, Poly atomic Molecules, Energy due to Stretch, Bend, Stretch-Bend, Torsional strain, van der Waals and Dipole-Diploe interactions. Types of Potentials: Lennard-Jones, Truncated Lennard-jones, Exponential-6, Ionic and Polar potentials. Types of Force Fields: AMBER, CHARMM, Merck Molecular Force Field, Consistent Force Field, MM2, MM3 and MM4 force fields.

**Unit 2** **5 Lectures**

**Potential Energy Surface**:- Convergence Criteria, Characterizing Stationary Points, Search for Transition States. Optimization:- multivariable Optimization Algorithms, Gradients, Optimization Criteria, Unidirectional Search, Finding Minimum Point, Gradient based Methods-Steepest Descent and Conjugate Gradient Methods

**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 .(discuss with expert)

**Unit 4** **8 Lectures**

**Molecular modelling in Drug design**:- Conformational analysis, lead identification, optimization and validation. Methods and Tools in Computer-aided molecular Design, Analog Based drug design:-Pharmacophores and QSAR. Structure based drug design:- Docking, De Novo Drug Design, Virtual screening

**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:**


1. Computational Chemistry and Molecular Modeling-Principles and Applications by Ramachandran, Deepa and Namboori, 2008, Springer_Verlag. Reference for Unit 1 and 2.
2. Molecular Modeling Principles and Applications (2nd Ed.) by Andrew R. Leach, Prentice Hall, USA. 2001


**Reference:**


1. Molecular Modelling for Beginners, (2nd Edition) by Alan Hinchliffe, John Wiley & Sons Ltd. 2008
2. Molecular Modeling and Simulation – An interdisciplinary Guide by Tamar Schlick, Springerverlag. 2000
3. Computational medicinal chemistry for drug discovery edited by Patrick Bultinck, Marcel Dekker Inc. 2004

## CBIO 712-SYSTEMS BIOLOGY

**Total Credits: 3** **Total: 45 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. **Scale-free networks:** Power laws, Hubs, ultra-small property, degree exponent, The Barabasi-Albert Model. Degree correlations: assortativity and disassortativity.

**Unit-III** **8 Lectures**

**Biological networks:** Complex Biological Systems, Types of Biological networks, Intra-cellular networks: Gene-regulatory network, Protein-interaction network, Metabolic networks and Signaling network; Inter-cellular networks: Neuronal networks, Network motifs, Network medicine.

**Unit-IV** **8 Lectures**

**Modularity:** Motifs and sub-graphs, Feed-forward loops, Single-input modules: LIFO, FIFO. Dense overlapping regulons (DORs). Optimal gene design circuits: fitness function and optimal expression of a protein in bacteria, Robustness.

**Unit-V** **10 Lectures**

**Constraint-based modelling** – Metabolic reconstruction, Flux Balance Analysis (FBA): Translating biochemical networks into linear algebra, Stoichiometric matrix, Elementary mode, Extreme pathways, Objective function, Optimization using linear programming. Genome-scale cellular models: Virtual Erythrocytes, Global human metabolic model (Recon 1).

**Text Books:**


1. Networks: An Introduction by M.E.J. Newman, Oxford University Press, 2010.
2. Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall/CRC, 2007.


**Reference Books:**


1. Introduction to Systems Biology, S. Choi, Humana Press, 2007.
2. Linked – The New Science of Networks, Albert-László Barabási, Perseus Publishing, 2002.

## CBIO 713-DATA MINING AND DATA WAREHOUSING

**Total Credits: 3** **Total: 45 Hrs*.**

**Unit 1** **8 lectures**

**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** **6 lectures**

**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** **8 lectures**

**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** **7 lectures**

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** **7 lectures**

**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:


1. Data Mining Concepts and Techniques – Jiawei Hen, Micheline Kambler, Academic Press Morgan Kaufman Publishers. 2006
2. Building Data Ware House by W.H.Inmon, John Wiley & Sons
3. Data warehousing by S. Anahory and D.Murray, Pearson Education, ASIA

## CBIO 714 - METABOLISM AND IMMUNOLOGY

**Total Credits: 3** **Total: 45 Hrs.***

**Unit 1** 6 **Lectures**

Basic enzymology: Enzyme nomenclature and classification of enzymes according to I.U.B. convention, General properties of enzymes, -. Enzyme kinetics, Michales-Menten, Lineweavar Burk, Factors effect Enzyme activity, Enzyme Inhibition, allosteric enzymes.

**Unit 2** **7 Lectures**

Overview of metabolism, high energy compounds, the reactions of glycolysis, fermentation, control of glycolysis. The pentose phosphate pathway, gluconeogenesis, glycogen breakdown and synthesis, control of glycogen metabolism. 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, Nucleic acid metabolism: Synthesis of purine ribonucleotides, synthesis of pyrimidiine ribonucleotides, formation of deoxyribonucleotides.

**Unit 4** 8 **Lectures**

**Introduction and Antibodies**: Innate and acquired immunity, active and passive immunity, natural and artificial immunity and humoral. Lymphoid system- primary or secondary organ. **Antibody generation:** structure and function –clonal selection theory-different types of immunoglobulins, antibody diversity. Complement system- activation, pathways and biological effects. Major Histochemical molecules/peptide complexes- Structure and Function. **Antigen and antibody reaction/interaction:** Precipitation, Haemagglutination, direct and indirect immunofluroescence

**Unit 5** **7 Lectures**

**Vaccine development and Immunoinformatics**: hybridoma technology for mass production. Chimeric antibodies, antibody engineering; large scale manufacture of antibodies. Recombinant vaccines, combined vaccines, polyvalent vaccines. Immunoinformatics, databases in immunology, DNA, Plant and protein based recombinant antigens as vaccines.

**Text book**:

1. Biochemistry by Voet and Voet. Wiley. 2011
2. Text book of Immunology by Kuby, 2008

**Reference Books:**

1. Principles of Biochemistry by Nelson and Cox, Lehninger. W H Freeman & Co. 2009
2. Biochemistry by Berg, Tymoczko & Stryer. W.H.Freeman and Co New York. 2007
3. Text book of Immunology by Riott, 2006

## CBIO 715-BIOPHYSICAL TECHNIQUES

**Total Credits: 2** **Total: 30 Hrs*.**

**Unit 1** **4 Lectures**

**Spectroscopy: Introduction to spectroscopy**: basic principles, instrumentation and applications of UV-VIS absorption, infrared, Raman, fluorescence spectroscopy

**Unit 2** **6 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** **4 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** **6 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** **6 Lectures**

**Membrane Biophysics and neuro Biophysics: Membrane Constituents** : Review of chemistry and biochemistry of constituents of membranes - lipids, phospholipids, lipoproteins, models of membrane structure. **Nervous System**: Organization of the nervous system - Membrane potentials - origins of membrane potential - electrochemical potentials - Donnan equilibrium - Nernst equation - Goldman equation.

**Reference Books:**


1. Biophysics, V. Pattabhi, N. Gautham, 2002, Narosa Publishing House
2. Guide to protein purification, 2nd edition, Methods in enzymology V463, JN. Abelson and Melvin I. Simon
3. Spectroscopy for the biological sciences, Gordon G. Hammes, John Wiley & Sons, Inc., Publication
4. Lehninger Principles of Biochemistry, Fourth Edition, David L. Nelson, Michael M. Cox
5. Introduction to biological membrane, Jain RK
6. Biomembrane structure and function, Chapman D

## CBIO 716 - PERL PROGRAMMING FOR BIOLOGISTS

**Total Credits: 2** **Total: 30 Hrs.***

**Unit 1** **6 Lectures**

**Perl Basic Data types:** Scalar Variables, Scalar Operations and Functions, Array Variables, Literal Representation of an Array, Array Operations and Functions, Scalar and List Context, Hash Variables, Literal Representation of a Hash, Hash Functions

**Unit 2** **4 Lectures**

**Perl Regular Expression:** Concepts on Regular Expressions, Uses of Regular Expressions in biological data handling, metacharacters, quantifiers, Pattern-matching, Substitutions, Transliteration, Split and join functions

**Unit 3** **4 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** **4 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** **6 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
2. Learning Perl (5th Ed.), Randal L. Schwartz, Tom Phoenix and Brain d foy, O'Reilly, 2008

**Reference Books**

1. Programming Perl (3rd Ed), L.Wall, T. Christiansen and J. Orwant, O'Reilly, 2007
2. Beginning Perl, Simon Cozens, Peter Wainwright. Wrox Press Inc., 2000

## CBIO - 751 PROJECT (PHASE – I)

**Total Credits: 1**

This process includes

a) the conceptualization of the independent research that will comprise the dissertation,
b) the preparation of and satisfactory defence of the dissertation proposal,
c) the collection, analysis, and interpretation of data,
d) preliminary report should be submitted and presentation for evaluation.

## CBIO 752-BIO-MOLECULAR SIMULATIONS - LAB

### Total Credits : 1

Exercises

1. Molecular Visualization: Pymol and Chimera

- Pdb file format and Parsing
- Visualizing a molecule in different representations
- Identifying interacting residues (protein and ligand interactions)
- Measuring distances between atoms
- B-factor visualization
- Image tracing and preparation

2. Small Molecule sketching using Marvin sketch and bond optimization in 2D & 3D format

- SDF, MOL2 file formats

3. Geometry Optimization using SwissPdb Viewer

- Energy Minimization of protein molecule
- Determining Maxima and Minima energy points

4. Binding Site Identification

- Different approaches for binding site identification
- Tools - Cast-P, POCASA, 3D ligand site, Metapocket, Ghecom

4. Structure based Drug design

- Molecular docking using AutoDock
- Virtual Screening using AutoDock Vina

5. Molecular Dynamics Simulation

- Protein dynamics using Gromacs
- Protein-ligand complex MD simulation

6. Ligand Based drug design

- QSAR

## CBIO 753-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 754- PERL PROGRAMMING FOR BIOLOGISTS -LAB

**Total Credit: 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

# Semester IV

## CBIO 721 – GENETIC ENGINEERING (rDNA Technology)

**Total Credits: 3** **Total 45 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.

**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, Gene amplification: Polymerase chain reaction, Primers, Real Time PCR and applications.

**UNIT III** **8 Lectures**

cDNA Synthesis and cDNA library preparations: Cloning mRNA enrichment, reverse transcription, Linkers, adaptors and their chemical synthesis, Library construction and screening. Genomic libraries (complete sequencing projects). Alternative Strategies of Gene Cloning Cloning interacting genes- screening for genes of interest – site directed mutagenesis – Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting.

**UNIT IV** **6 Lectures**

Gene Regulation methods: S1 mapping, RNase protection assay, Reporter assays. Transgenic and Gene Knockout Technologies including CRISPR Cas, Targeted gene replacement, Strategies of gene delivery, gene regulation silencing and transcription factors. Differential gene expression.

**UNIT V** **7 Lectures**

Expression Strategies for Heterologous Genes, Vector engineering and codon optimization, host engineering, *In-vitro* transcription and translation, expression in bacteria, expression in Yeast, expression in insects and insect cells, expression in mammalian cells, expression in plants. Processing of Recombinant Proteins Purification, Characterization of recombinant proteins. Transgenic plants, animals, genetically modified organisms (GMO) and GM food.

**BOOKS**


1. *Molecular Cloning, a Laboratory Manual,* J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, ,1st edition, 2000.
2. *DNA Cloning- a Practical Approach,* .M. Glover and B.D. Hames, IRL Press, Oxford, 1st edition, 1995.


**REFERENCES:**


1. *Molecular and Cellular Methods in Biology and Medicine*, P.B. Kaufman, W. Wu. D. Kim and L.J; Cseke, CRC Press, Florida, 6th edition,2006.
2. Lewin's GENES XI by Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick (Dec 31, 2012)

3. *Methods in Enzymology* vol. 152, *Guide to Molecular Cloning Techniques*, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 2nd edition,1998,
4. *Methods in Enzymology* Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990.
5. *DNA Science. A First Course in Recombinant Technology*, D,A. Mickloss and G.A. Froyer. Cold Spring Harbor Laboratory Press, New York, 1st edition, 1990.
6. *Molecular Biotechnology*, S.B. Primrose. Blackwell Scientific Publishers, Oxford, 2nd Edition, 1994.
7. *Milestones in Biotechnology. Classic papers on Genetic Engineering, J*.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 2nd edition, 1992.
8. *Route Maps in Gene Technology*, M.R. Walker and R. Rapley, Blackwell Science Ltd., Oxford, 6th edition, 2001.

## CBIO 722 - BIOMEDICAL INFORMATICS AND TRANSLATIONAL RESEARCH

**Total Credits: 2** **Total 30* Hrs***

**Unit I** **6 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**

Biomedical data - Their acquisition, storage and use, Electronic health records (EHR), Information Retrieval from Digital Libraries, Imaging Systems in Radiology and Picture archiving. Genomics and Proteomics data - Human Genome project, HapMap and 1000 genomes projects, Genetic profiling of individuals and large populations, Creation and use of Bioinformatics databases - gene, metabolic pathways of diseases.

**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; Ilustrative 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:**


1. Biomedical Informatics: computer applications in Health care and Biomedicine (3rd ed), by Shortliffe EH, Ciminio JJ., 2000, New York Springer-Verlag, ISBN 0-387-28986-0.
2. Translational Research in Genetics and Genomics, Ed. Moyra Smith; 2008, Oxford University press, ISBN: 978-0-19-531376-5.


**Reference Books:**


1. Evaluation methods in medical Informatics by Friedman CP. Wyatt JC, 1996, New York Springer Verlag, ISBN 0-387-25899-2.
2. Biomedical Informatics in Translational Research, Ed. Hai Hu, Richard J. Mural and Michael N. Liebman, 2008 Artech House, INC, ISBN-13: 978-1-59693-038-4.

## CBIO 723 - NEXT GENERATION SEQUENCE ANALYSIS

**Total Credits: 2** **Total: 30 Hrs*.**

**Unit-I** 6 **Lectures**

**NGS Platforms:** Introduction to NGS, WGSS, Second-generation DNA sequencing: Pyrosequencing, Reversible Dye-Terminator Sequencing, Emulsion PCR approach with small magnetic beads, Ion semiconductor sequencing, Ion torrent, Third-generation DNA sequencing: Single molecule real time (SMRT) sequencing, Fourth-generation nanopore-based sequencing.

**Unit-II** **6 Lectures**

**Genome assembly algorithms:** Alignment of short-reads to reference genome using spaced seed (ELAND, SOAP), index-filtering algorithm (SeqMap), quality-score (RMAP), q-grams 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).

**Unit-III** 6 **Lectures**

***De-novo* assembly:** Overlap-layout-consensus (OLC) approach (Arachne, Phusion), de Bruijn and Euler path approach (Euler, SOAPdenovo), string graph assembler (SGA). Scaffolding: Supercontig, contig orientation, contig ordering, contig distancing and gap closing using SOAPdenovo, ABySS, OPERA and RACA.

**Unit-IV** 4 **Lectures**

**Big Data and R language in NGS analysis:** Elements of Big data and R, Introduction to Bioconductor, Reading of RNA-seq data (ShortRead, Rsamtools, GenomicRanges), annotation (biomaRt, genomeIntervals), reads coverage and assign counts (IRanges, GenomicFeatures), differential expression (DESeq).

**Unit-V** 4 **Lectures**

**Biological applications of NGS:** Whole-genome sequencing, Exome sequencing, Transcriptome sequencing, Small RNA sequencing, Genotyping and Genome Variation discovery, DNA-Protein Interactions (CHIP-Seq), Epigenomics and DNA methylation analysis, Metagenome analysis.

**Text Books:**


1. Next-generation DNA sequencing Informatics by Stuart M. Brown, Cold Spring Harbor Laboratory, 2013.
2. Big Data Analysis for Bioinformatics and Biomedical Discoveries by Shui Quing Ye. Chapman and Hall/CRC Press, 2016.


**Reference Books:**


1. Next generation sequencing: Translation to Clinical Diagnostics by Wong Lee-Jun C. (ed.), Springer, 2013.
2. Next-generation genome sequencing: Towards Personalized Medicine by Michal Janitz, Wiley-VCH, 2008

## CBIO 724 - RESEARCH METHODOLOGY AND FINISHING SCHOOL

**Total Credits: 2** **Total: 30 Hrs*.**

**Unit 1** **5 Lectures**

**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; Data Collection - Data Analysis - Interpretation of results and Report writing.

**Unit 2** **6 Lectures**

**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** **4 Lectures**

**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** **5 Lectures**

**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** **6 Lectures**

**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:**


1. Scientific Writing: Easy When You Know How by Jennifer Peat, BMJ books. 2002
2. Successful Scientific Writing: A step-by-step Guide for Biomedical Scientists (3rd Ed.) by J.R. Matthews and R.W. Matthews, Cambridge University Press. 2008


**References:**


1. From Research to Manuscript: A Guide to Scientific Writing by Michael Jay Katz, by Springer. 2006
2. Writing and Presenting Scientific Papers, 2nd Edition by Brigitta Malmfors, Phil Garnsworthy and Michel Grossman, Nottingham University Press, 2004, Viva Books Pvt. Ltd. 2011
3. Scientific Writing- A Reader and Writer's Guide, by Jean Luc- Lebrun, World Scientific Publishers, 2007

## CBIO- 755 PROJECT (PHASE – II)

**Total Credits: 6**

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.