M.Sc. BIOINFORMATICS

REGULATIONS AND SYLLABI

(Effective from 2023-2024)

Department of Bioinformatics

SCHOOL OF LIFE SCIENCES

PONDICHERRY UNIVERSITY

PUDUCHERRY

Pondicherry University
School of Life Sciences
Department of Bioinformatics

Master of Science in Bioinformatics

The M.Sc Bioinformatics Program started since 2007 under UGC Innovative program

Program Objectives

The main objective of the program is to train the students to learn an innovative and evolving field of bioinformatics with a multi-disciplinary approach. Hands-on sessions will be provided to train the students in both computational and experimental labs.

Program Outcomes

On completion of this program, students will be able to:

- Gain understanding of the principles and concepts of both biology along with computer science
- To use and describe bioinformatics data, information resource and also to use the software effectively from large databases
- To know how bioinformatics methods can be used to relate sequence to structure and function
- To develop problem-solving skills, new algorithms and analysis methods are learned to address a range of biological questions.

Eligibility for M.Sc. Bioinformatics

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

- Bachelor's degree in any relevant area of Physics / Chemistry / Computer Science / Life Sciences with a minimum of 55% of marks

Minimum number of credits required to be earned by students

The minimum number of credits required to be earned by students of M.Sc. Programmes

Sl.No.	Programme	Credits for Hard Core Courses	Credits for Soft Core Courses	Minimum credits required for award of degree
1	M.A./M.Sc./M.Tech. (except M.Tech ECE) / Any other 2 year P.G. Programme not mentioned below	48 to 60	12 to 24	72

A candidate who has passed in all the Hard-Core courses and Project Work (if any) and accumulated not less than the minimum number of Credits prescribed shall be eligible to receive the Degree

PONDICHERRY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOINFORMATICS

LIST OF HARD-CORE COURSES FOR M.Sc. BIOINFORMATICS

(Academic Year 2023-2024 onwards)

Course Code	Course Title	H	Credits	Pg. No
Semester I				
BINF 411	Cell and Molecular Biology	H	3	8
BINF 412	Bioinformatics Databases	H	3	10
BINF 413	C, C++ and Data Structures	H	3	12
BINF 451	**Lab** - Cell and Molecular Biology	H	1	22
BINF 452	**Lab** - Biological Databases	H	1	23
BINF 453	**Lab** - Programming in C/ C++	H	1	24
	Total Credits		**12**	
Semester II				
BINF 430	Genomics and Proteomics	H	3	27
BINF 422	Bioinformatics: Sequence Analysis	H	3	29
BINF 423	Programming in Java	H	3	31
BINF 424	Database Management System	H	3	32
BINF 425	Fundamentals of Algorithms	H	3	33
BINF 459	**Lab** - Programming in Java	H	1	37
BINF 457	**Lab** – Programming in DBMS	H	1	38
BINF 458	**Lab** - Biosequence Analysis	H	1	39
	Total Credits		**18**	
Semester III				
BINF 511	Structural Biology	H	3	41
BINF 512	Molecular Modeling and Drug Design	H	3	43
BINF 513	Programming in Perl	H	3	45
BINF 514	Systems Biology	H	3	46
BINF 515	Data Mining and Machine Learning	H	3	48
BINF 551	**Lab** - Structural Biology	H	1	56
BINF 552	**Lab** - Molecular Modeling and Drug Design	H	1	57
BINF 553	**Lab** - Programming in Perl	H	1	58
	Total Credits		**18**	
Semester IV				
BINF 521	Bioethics, Biosafety and Intellectual Property Rights	H	3	60
BINF 429	Molecular evolution	H	3	62
BINF 554	Project	H	6	65
	Total Credits		**12**	

*30 Hrs for 2 Credit paper (24 Lectures + 6 Tutorials)

*45 Hrs for 3 Credit paper (36 Lectures + 9 Tutorials)

PONDICHERRY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOINFORMATICS
LIST OF SOFT-CORE COURSES FOR M.Sc. BIOINFORMATICS

(Academic Year 2023-2024 onwards)

Course Code	Course Title	S	Credits	Pg. No
Semester I				
BINF 420	Physics for Biologists[+]	S	2	13
BINF 415	Chemistry for Biologists[+]	S	2	15
BINF 416	Mathematics for Biologists[+]	S	2	16
BINF 417	Fundamentals of Biology	S	2	17
BINF 421	Fundamentals of computing and operating system [#]	S	2	19
BINF 419	Introduction to Bioinformatics[*]	S	3	20
BINF 455	Lab - Bioinformatics databases and tools[*]	S	1	25
Semester II				
BINF 426	Biostatistics [#]	S	2	34
BINF 427	Microscopic Techniques for Image Processing	S	2	35
BINF 428	Animal Cell Culture and Technology	S	2	36
Semester III				
BINF 517	Spectroscopy in Biology	S	2	50
BINF 518	Plants System biology	S	2	51
BINF 519	Introduction to Biophysics	S	2	52
BINF 520	Research Methodology and Finishing School	S	3	54
Semester IV				
BINF 523	Biophysical Techniques	S	3	66
BINF 524	R language and Big Data Analytics	S	2	67
BINF 525	Macromolecular Crystallography	S	3	68
BINF 528	Computer-aided drug design: Fundamentals & Applications *	S	2	70
BINF 529	Python Programming for Biologists	S	3	63
BINF 527	Python Programming Laboratory	S	1	72

+ Physics, Chemistry and Mathematics are compulsory for students having UG degree in Biological Sciences.

*** Exclusively for students from other departments.**

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

SEM-I

BINF 411 - CELL AND MOLECULAR BIOLOGY

COURSE OBJECTIVES: *The main objective of the course is students to understand the structure and function of living systems at the molecular level and the biological features of different types of micro-organisms*

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

Unit 1 **9 lectures**

Molecules of life: Water importance for life-Cellular Foundations-Biomolecules- Structural organization of prokaryotic and eukaryotic cells- Concept of a composite cell and Molecular composition of cells. Biomembranes- Structural organization - Models of a plasma membrane, Membrane permeability - Transport across cell membranes - Transmembrane signals - Artificial membranes - liposome, Eukaryotic Cell Cycle: mitosis and meiosis.

Unit 2 **9 lectures**

Cellular Organelles: Cytoskeleton – components of Cytoskeleton, Microtubules, Intermediate filaments – Microfilaments, Endoplasmic reticulum, Golgi complex, Types of m,\vesicles - transport and their functions, Lysosomes. Nucleus - Internal organization, Nuclear pore complex, Nucleosomes, Chromatin.

Unit 3 **9 lectures**

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

Unit 4 **9 lectures**

Mitochondrial Genome, Structure and Function: Oxidative Metabolism in the Mitochondrion – The Role of Mitochondria in the formation of ATP – Translocation of Protons and the Establishment of a proton-motive force – The Machinery for ATP formation – Peroxisomes. Genome studies of Mitochondria.

Unit 5 **9 lectures**

DNA and Protein Synthesis: Structure of DNA - evidence for DNA as genetic material. Gene transfer in microorganisms – conjugation, transformation, transduction - protoplasmic fusion. The genomes of bacteria, viruses, plasmids. DNA Structural organization - DNA replication, Transcription – mRNA processing, Translation. Protein synthesis – Ribosomes, enzymes, Protein processing, Introduction to the methods of DNA sequencing – Gene Regulation.

Text Books:

1. Cell and Molecular Biology – Concepts and Experiments by Gerald Karp. Wiley International Student Version. 2015
2. Campbell Biology (9^{th} Ed) by Campbell, Reece & Co. Pearson Benjamin Cummings, San Francisco. 2015
3. Genes X11 by Lewin, B, Pearson Education International. 2017
4. Cell and Molecular Biology 8/E by De Robertes and De Robertis. Saunders College, Philadelphia, USA. 2011

Reference Books:

1) Principles of Biochemistry by Nelson and Cox, Lehninger. W H Freeman & Co. 2017
2) Biochemistry by Jeremy M. Berg, John L. Tymoczko & Lubert Stryer. 2015.

Course outcome: *Students gained the knowledge in the field of molecular biology.*

BINF 412 - BIOINFORMATICS DATABASES

***COURSE OBJECTIVES**: To introduce most of the effectively used Bioinformatics databases and their applications in the field of Bioinformatics.*

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

Unit 1 **9 lectures**

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

Unit 2 **9 lectures**

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

Unit 3 **9 lectures**

Protein Sequence Databases: Swiss-Prot, TrEMBL, UniProt, UniProtKB, UniParc, UniRef, UniMES; Sequence motifs Databases:- Prosite, ProDom, Pfam, InterPro, GeneOntology; Sequence file formats:- GenBank, FASTA, PIR, ALN/ClustalW2. Polymorphism and mutation databased- BioMuta, dbSNP- Database of short Genetic Variation, DMDM- Domain Mapping of Disease Mutations.

Unit 4 **9 lectures**

Structure and derived databases: Primary structure databases:- PDB, NDB, MMDB; Secondary structure databases:-Structural Classification of Proteins –SCOP, Class Architecture Topology Homology –CATH, Families of Structurally Similar Proteins –FSSP, Catalytic Site Atlas –CSA; Molecular functions / Enzymatic catalysis databases:- KEGG ENZYME database; Protein-Protein interaction database:- STRING, BioGRID, MINT; Chemical Structure database:- Pubchem, DrugBank, ChEMBL; Gene Epression database:- GEO, SAGE.

Unit 5 **9 lectures**

Bioinformatics Database search engines: Text-based search engines (Entrez, DBGET / LinkDB). **Sequence** similarity based search engines (BLAST and FASTA). Motif-based search engines (ScanProsite and eMOTIF). Structure similarity based search engines (Combinatorial Extension, VAST and DALI). Proteomics tools: - ExPASy server, EMBOSS.

Text Books:

1. 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
2. Essential Bioinformatics by Jin xiong.,Combrridge University press,New York.2006

Reference Books:

1. Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
2. lntroduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson Education. 1999 Old editions

COURSE OUTCOME*: Students will understand the databases available and their applications in the field of Bioinformatics, Biomedical research, etc.*

BINF 413 – C, C++ AND DATA STRUCTURES

COURSE OBJECTIVES: *To train the students in writing programs in C- language and to introduce them to the concepts of object-oriented language through C++.*

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

Unit 1 **9 lectures**

Introduction to C: C language Introduction – Tokens – Keywords, Identifier, Variables, Constants, Operators – Expression – Data types – Operator precedence - Statements: Input statement, Output statement.

Unit 2 **9 lectures**

Controls and loops: Conditional and Unconditional Control Statement – LoopingStatements: while, do-while, for – Nested loops – Arrays.

Unit 3 **9 lectures**

Procedural Concept: Structured Programming – Built-in library function – User defined functions – Pointer introduction – Passing a pointer to a function – Structure – Union – File handle: Read and Write numerical and character data from/to a file.

Unit 4 **9 lectures**

String Handling & Sorting: String declaration – String library functions - String Manipulation - Sorting: Bubble sort, Selection sort, Insertion sort – Searching: Linear search, Binary search.

Unit 5 **9 lectures**

Object Oriented Programming: Programming in C++ – C++ programming – Object Oriented Concept: Encapsulation, Inheritance, Polymorphism – Different forms of Constructors – Destructors – Abstract class – Virtual function.

Text Books:

1. Programming in ANSI C by E. Balagurusamy. Tata McGrawHill Publishing Company Limited. 2007
2. Object Oriented Programming using C++ (4^{th} Edition) by Lafore, R. Galgotia Publishers. 2008

Reference Books:

1. Sams Teach Yourself C++ in 24 hours (5^{th} edition) by Jesse Liberty and Rogers Candenhead, Pearson Education Inc., 2012.
2. Head First C by David Griffiths and Dawn Griffiths, O'Reilly. 2013.

COURSE OUTCOME: *On successful completion of the course students will get familiarize with coding for bioinformatics problems in C/C++ language and with the object-oriented programming approach.*

BINF 420 – PHYSICS FOR BIOLOGISTS

COURSE OBJECTIVES: *The main objective of this course is to help the students to understand the basic concept of fundamental physics and their applications in biology.*

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

Unit 1 **6 lectures**

Mechanics and Dynamics: Newton's Equation of Motion: Derivations of Graphical, differential and integral form equation of motions. Derivation of angular equation of motions elastic and inelastic collisions, impulse and momentum theorem. The forces Gravitational force, Electromagnetic Force Nuclear Force and Weak Force. Vector form of torque and angular momentum. Angular momentum of system of particles, forces of friction, dissipation, inertia and disorder. **Work and energy**:- work energy theorem, conservative and non-conservative forces, kinetic and potential energy.

Unit 2 **6 lectures**

Quantum Mechanics: Black body radiation, photoelectric effect, Dalton, JJ Thomson and Rutherford atomic theory. Bohr's Model of Hydrogen atom, De Broglie's Hypothesis, Harmonic wave function, phase velocity, group velocity, and wave packets, Compton effect and scattering Heisenberg uncertainty principle, eigen states and eigen values, Pauli's exclusion principle, one and three dimensional time dependent Schrodinger equation. Particle in a box, 1-D to 3-D, spectral transitions, conjugated systems explained using PIB.

Unit 3 **6 lectures**

Thermodynamics: Definitions and Fundamental Ideas of Thermodynamics:- 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**:- The First Law of Thermodynamics, Work, Entropy, **The Second Law of Thermodynamics**:- reversibility and irreversibility, free and isothermal expansions, **Heat Capacity:-** Heat Capacity, ratio of the heat capacities of a Gas, Isothermal and reversible-adiabatic expansion of an Ideal Gas , **Enthalpy:-** Enthalpy, Change of state, Latent heat and Enthalpy, **Heat engines**:- Carnot cycle, **Free Energy**:- Gibbs and Helmholtz free energy, The Third Law of Thermodynamics.

Unit 4 **6 lectures**

Electricity - Electrostatic Field: Electric charge, Coulomb's Law, electric flux, Gauss's law, and applications of gauss's law Electric field due to point charge, Electric field due to line charge and electric field due to sheet of charge. Electric field due to conducting cylinder and electric field due to charged conduction plates, **The Electric Potential**:- Potential of a Point Charge and Groups of Points Charges, Potential Due to a Continuous Charge Distribution.

Unit 5 **6 lectures**

Electromagnetic waves: Electromagnetic spectrum - and Diffraction, Classification of diffraction, **Fresnel diffraction**:- single narrow slit, **Fraunhofer diffraction**:- Single slit, double slit. **Diffraction patterns**:-Diffraction patterns from narrow slits, Resolution of single-slit and diffraction grating, Diffraction of X-rays by crystals.

Text Books:

1. Physics for Scientists and Engineers (6th Ed.) by Raymond A. Serway, John W. Jewett, Thomson Brooks/Cole, 2004.
2. Physics of the Life Sciences by Jay Newman, Springer, 2008.

Reference Books:

1. Physics for Scientists and Engineers by Paul A. Tipler, Gene P. Mosca. Freeman Company. 2007.
2. Fundamentals of Physics by Resnick, Halliday and Walker, 2001
3. Quantative understanding of biosystems, An introduction to biophysics, Thornas M. Nordlund (2011)

COURSE OUTCOME: *Students gained the knowledge of concept of fundamental physics and their applications in biology.*

BINF 415 – CHEMISTRY FOR BIOLOGISTS

COURSE OBJECTIVES: *To train the students in the field of basic chemistry to understand the biology*

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

Unit 1 **6 lectures**

Atomic and Molecular Structure: Atomic Structure - Elements and compounds, atoms and molecules-definition, Classical atomic models - J. J. Thomson, E. Rutherford, N. Bohr. Quantum mechanical model. Electronic configuration - aufbau principle - Pauli exclusion principle - Hund's rule Modern periodic table, periodicity. **Chemical bonds** - ionic bonding - covalent bonding - Coordinate covalent bonding. Overlapping of atomic orbital to form σ and π bond with example. Meaning and Difference between σ and π bonds – hybridization, resonance. Bond properties. Molecular geometry. Intermolecular forces.

Unit 2 **6 lectures**

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

Unit 3 **6 lectures**

Introduction to Organic chemistry: Position of Carbon in periodic table, tetra covalency of carbon, catenation, functional groups, formal charge, oxidation number, aromaticity, electrophiles and nucleophiles, organic acids and bases, types of organic reactions (eg., SN1 and SN2).

Unit 4 **6 lectures**

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

Unit 5 **6 lectures**

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

Text Books:

1. Organic Chemistry by Paula Yurkanis Bruice, Prentice Hall. 2010
2. Organic Chemistry, 7th edition by Morrison Boyd & Bhattacharjee, Pearson Education India, 2010.

Reference Books:

1. Chemistry^3: Introducing inorganic, organic and Physical Chemistry; Andrew Burrows, John Holman, Andrew Parsons, Gwen Pilling, and Gareth.

COURSE OUTCOME: *Students gained the knowledge of basic and fundamental chemistry to understand the biological macromolecular structure.*

BINF 416 – MATHEMATICS FOR BIOLOGISTS

COURSE OBJECTIVES: *To give a bridge course to students who has not studied mathematics in their undergraduate studies*.

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

Unit 1 **6 lectures**

Matrices: Properties of Determinants, Minors and Cofactors, Multiplication of Determinants, Adjoint, Reciprocal, Symmetric Determinants, Cramer's rule, Different types of matrices, Matrix Operations, Transpose of a matrix, Adjoint of a square matrix, Inverse of a matrix, Eigen values and eigen vector.

Unit 2 **6 lectures**

Trigonometry and Analytical Geometry: Trigonometric ratios, De Moivre's theorem, The general equation of a Straight line, slope of a line, intercepts of a line, Angle between two lines, Intersection of two lines, The general equation of a Circle.

Unit 3 **6 lectures**

Calculus: Differential Calculus- Derivative of a function, Concept of limit, Continuity, Differentiation, Maxima and Minima of a function, Introduction to Partial Differentiation, Integral Calculus: The Idea of the Integral, The Definite Integrals, Indefinite Integrals.

Unit 4 **6 lectures**

Fourier Transformations : Properties of Fourier Transformations – Fourier Transformation of a convolution – Inverse Fourier Transformations.

Unit 5 **6 lectures**

Numerical Methods: Solution of algebraic and transcendental equations: Bisection method, Method of false position / Regula-falsi method, Newton-Raphson method.

Text Books:

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

Reference Books:

1. Basic Mathematics by Serge A. Lang. Springer Publisher. 1988
2. A First Course in Calculus by Serge A. Lang. Springer publisher. 1986
3. Higher Engineering Mathematics (40^{th} Ed), by B.S. Grewal and J.S. Grewal. Khanna Publishers, New Delhi. 2007.

COURSE OUTCOME: *The students will gain skills in solving mathematical problems which are essential to understand advanced courses in Bioinformatics.*

BINF 417 – FUNDAMENTALS OF BIOLOGY

COURSE OBJECTIVES: *Students will understand the evidences explaining the descendance of life forms, nomenclature rules and systemic classification. Help them understand the inheritance pattern and practical methodology for applying the mendelian genetics along with effect of mutation and crossing over influencing the process of linkage in determining the sexes and heritable diseases.*

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

Unit 1 **4 Lectures**

Origin and Biodiversity: Classification of the living organisms (five kingdom classification, major groups and principles of classification within each kingdom). Systematics and binomial System of nomenclature (Linnaean classification). Salient features of animal (non-chordates up to phylum level and chordates up to class level) and plant (major groups; Angiosperms up to class level).

Unit 2 **7 Lectures**

Structural and reproductive biology: Morphology and anatomy of different Biological systems (earthworm, cockroach etc). Morphology and anatomy of flowering plants; Asexual reproduction, Sexual reproduction, Alternation of generations in plants.

Unit 3 **7 Lectures**

Classical Genetics: Mendelian inheritance (Chromosome theory of inheritance), deviations from Mendelian ratio (gene interaction- incomplete dominance, co-dominance, multiple alleles). Sex determination in human beings: XX, XY. Linkage and crossing over (role of mutagens in chromosomal disorders with emphasis to human beings).

Unit 4 **6 Lectures**

Ecosystem: History, process- Primary production, Energy flow (food web and tropical levels), Decomposition and nutrient cycles. geographical and environmental variations- Components of variation, adaptive features and selection. Human activities- threats and management practices.

Unit 5 **6 Lectures**

Evolution: History- Classical times, Medieval, Pre-Darwinian, Darwinian revolution, Pangenesis and heredity and the modern synthesis. Mechanisms- Natural selection, Biased mutation, Genetic drift and Genetic hitchhiking, gene flow and their outcomes including adaptation, co-evolution, co-operation, speciation and Extinction.

Text Books:

1. Life: The Science of Biology, 10th Edition by David E. Sadava, David M. Hillis, H. Craig Heller and May Berenbaum-2012.
2. Molecular Biology of the cell by Bruce Alberts, Garland publishing Inc. 2002.
3. Futuyma, Douglas J. and Kirkpatrick, Mark (2017). "Evolutionary Biology". Evolution (Fourth ed.). Sunderland, Massachusetts: Sinauer Associates, Inc

Reference Books:

1. Cell - A molecular approach by Cooper. G. M., Oxford University Press. 2000

2. The Economy of Nature by Robert E. Ricklefs and Rick Relyea. Publisher- W. H. Freeman 6th ed, 2008.

3. Genetics: A Conceptual Approach 6th ed by Benjamin A. Pierce-2017

4. Schoener, Thomas W. (2009). "Ecological Niche". In Simon A. Levin. The Princeton Guide to Ecology. Princeton: Princeton University Press

5. Lynch, Michael (May 15, 2007). "The frailty of adaptive hypotheses for the origins of organismal complexity". Proc. Natl. Acad. Sci. U.S.A. 104 (Suppl. 1): 8597–8604.

6. Zimmer, Carl (January 7, 2016). "Genetic Flip Helped Organisms Go From One Cell to Many". The New York Times. New York.

COURSE OUTCOME: *The students will be able to explain the basics of biology, classification of the living organisms, nomenclature, Morphology and anatomy of different Biological systems existing on earth and also principles of genetics and evolution.*

BINF 421 – FUNDAMENTALS OF COMPUTING AND OPERATING SYSTEM

COURSE OBJECTIVES: *To understand the basic knowledge on computer, network & Internet terminologies and problem-solving techniques.*

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

Unit 1 **6 lectures**

Computer Organization: Working architecture of the Computer – Comparison of various storage devices-Digital Computers and Digital Systems, Computer Types, Functional Units, Basic Operational Concepts, Introduction to diverse computing platform and its analogy.

Unit 2 **6 lectures**

Network Basics: Definition of Computer Networks, OSI Architecture of Network Layers, Applications of Computer Networks - Network variation based on area coverage - Topological arrangement of various network – Virtual Private Network (VPN) – Comparison of VPN and Network - Wireless communication – Biological network.

Unit 3 **6 lectures**

Problem Solving Techniques: Algorithm & Flowchart for Biological problem, Overview of programming language Hierarchy – Development of source code in C language – Compilation and Execution of the problem – Refinement of source code by Testing and Debugging – Preparation and Maintenance of document for future reference – Application of Utility programs (Backup software, Disk checkers, Security utilities, Firewall and spyware protection).

Unit 4 **6 lectures**

Internet Technologies: Introduction to diverse Internet terminologies - Domain Name System – Function and Services of Internet Protocol Address – Services of Internet and Internet Service Provider (ISP) – Architecture of the Internet – Introduction to Cyber Forensics (Cyber Crime, Cyber Security and Threads), Overview of Internet of Things (IOT).

Unit 5 **6 lectures**

Unix and Shell Programming: Introduction to Linux, Linux File System and Text Editing, File content manipulation and processing, Introduction to environment variables and sample software installation –Introduction to I-Node concept – Example of Simple filters (grep command).

Text Books:

1. Dharmendra B. Kadia. 2010. Basic Knowledge of Computer. 1st Edition.
2. Peek Jerry. 2002. Learning the UNIX Operating System. O'Reilly Media, Inc, USA. ISBN: 9780596002619, 0596002610.
3. M. Morris Mano, "Digital Logic and Computer Design", Pearson, 2012

Reference books:

1. V. Rajaraman and Neeharika Adabala. 2015. Fundamentals of Computers. 6th Edition, PHI Learning Pvt. Ltd.
2. Narasimha Karumanchi. 2017. Elements of Computer Networking. Career Monk publications.
3. V. Rajaraman. 2013. Introduction to Information Technology. 2nd Edition. PHI Learning pvt. Ltd.

COURSE OUTCOME: *Able to work in different operating systems and to learn shell programming that helps to handle UNIX which is mandatory for Bioinformatics.*

BINF 419 - INTRODUCTION TO BIOINFORMATICS

COURSE OBJECTIVES: *The main objective of this soft course is to introduce general concepts of Bioinformatics to the allied department students of Pondicherry University.*

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

Unit 1 **9 lectures**

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

Unit 2 **9 lectures**

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

Unit 3 **9 lectures**

Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; **Structure Databases**: PDB, NDB, PubChem, ChemBank. **Sequence file formats:** Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. **Protein and nucleic acid properties:** Proteomics tools at the ExPASy server, GCG utilities and EMBOSS, Computation of various parameters.

Unit 4 **9 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.

Unit 5 **9 lectures**

Sequence alignment: Measurement of sequence similarity; Similarity and homology. **Pairwise sequence alignment:** Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

Text Books:

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

Reference Books:

1. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, Pearson Education. 1999
2. Bioinformatics for Dummies by Jean-michel Claverie Cedric Notredame. Publisher: Dummies (Jan 2007)

COURSE OUTCOME *The outcome of the paper is students from other departments gained the knowledge of how to utilize bioinformatics resources.*

BINF 451 - LAB - CELL AND MOLECULAR BIOLOGY

COURSE OBJECTIVES: *Students will gain hands on experience of various instruments used in experimental techniques to understand the basic experimental procedures and techniques in cell and molecular biology.*

Total Credits: 1

Exercises in Cell Biology

Observation of Eukaryotic cells with the help of light microscope

Estimation of Chlorophyll

Ascorbic acid estimation in different tissues of plants and animals.

Mitosis and the cell cycle in onion root-tip cell

Isolation of mitochondria and assay for function.

Exercises in Molecular Biology

Isolation & Purification of genomic DNA from bacteria

Isolation & Purification of plasmid DNA

Agarose gel electrophoresis of chromosomal & plasmid DNA

Restriction Digestion of chromosomal & plasmid DNA

Isolation of DNA fragment from agarose gel

PCR for DNA amplification

Protein separation using HPLC (demo)

Protein separation using SDS-PAGE

COURSE OUTCOME:

The course will help student to understand about various experimental techniques, usage of laboratory instruments, learn the principles of laboratory usage and its guidelines.

BINF 452 - LAB - BIOLOGICAL DATABASES

COURSE OBJECTIVES: *To make the students familiarized with the Bioinformatics databases and their applications*

Total Credits: 1

Exercises:

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

2. Database search engines: Entrez, DBGET

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

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

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

6. Structure Databases: PDB, NDB, PubChem, ChemBank, FSSP, DSSP

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

8. Sequence file formats: GenBank, FASTA

9. Protein and nucleic acid properties: Proteomics tools at the ExPASy server, EMBOSS

COURSE OUTCOME: *Students will understand the information's available in Bioinformatics databases and their applications in research*

BINF 453 - LAB - PROGRAMMING IN C/ C++

COURSE OBJECTIVES: *To give practical training in writing codes in C and C++ programming languages.*

Total Credits: 1

LINUX Operating System: Overview of Linux Architecture and Basic commands

C

1. Simple Input and Output statements.
2. Working with if, if else and switch constructs.
3. Working with arrays and strings.
4. Loops and nested loops.
5. Working with user defined functions.
6. Working with pointers.
7. Working with structures and Unions.
8. File handling with numerical and character data.

C++

9. Creation of a simple class and working with its objects.
10. Implementing the inheritance in C++.
11. Working with function overloading.
12. Working with operator overloading.

COURSE OUTCOME: *At the end of the course, students will be able to write, compile and run the programs in C/C++ for bioinformatics problems.*

BINF 455 - LAB - BIOINFORMATICS DATABASES AND TOOLS

COURSE OBJECTIVES: To provide hand on train on bioinformatics databases and tools for allied department students.

Total Credits: 1

1. Entrez and Literature Searches
    a. PubMed
    b. PubMed central
    c. OMIM / OMIA
    d. Citation matcher
2. SRS of Biological Databases
    a. Nucleotide/ Genome Databases.
    b. Protein Sequence Database.
    c. Structure Databases.
    d. Protein Pattern Databases
3. File format conversion
    a. FmtSeq
    b. ReadSeq
    c. Sequence manipulation Suite
4. Sequence Analysis
    a. Dot Plot
    b. Pairwise alignment
    c. Multiple Sequence Alignment
5. Software
    a. BioEdit
    b. GeneDoc
    c. ClustalW / X, MEGA, MEME
6. Visualization Tool
    a. RasMol
    b. Cn3D
    c. PYMol

COURSE OUTCOME: *Students will be trained how to use the bioinformatics databases and tools.*

SEM-II

BINF 421 – GENOMICS AND PROTEOMICS

COURSE OBJECTIVES: *The goal is to determine how all the genes in a genome act and how their products interact to produce a functional organism. The different methods of sequencing, microarrays, protein fingerprints and the role of bioinformatics tools applied to analyse and interpret the protein-protein interactions in different cell types will be detailed.*

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

Unit 1 **9 Lectures**

Introduction to genome Techniques: The origin of genomes- Pre- and post-genomic era, acquisition of new genes by gene duplication, Gene families – types, Pseudogenes. Origin of gene families (lateral gene transfer, allopolyploidy). Mapping genomes: Genetic mapping – Cross breeding and pedigree analysis, DNA markers - RFLPs, SSLPs and SCAR. Physical mapping - Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid, mapping and Sequence tagged site mapping.

Unit 2 **9 Lectures**

Genomics: Major advancements in genomic approaches- Genome projects: The Human genome project, HapMap Project, the 1000 genome project, and The ENCODE Project. Introduction to epigenetics and metagenomics; forward versus reverse genetics. Genome sequence- Methods for DNA/RNA sequencing, sequence analysis, Applications of Next-Generation Sequencing (NGS), Genome assembly annotation, Gene networks. Application of databases and tools for the prediction of genes, promoters, splice sites, regulatory regions, identification of disease genes, identification of SNPs, identification of Drought stress response genes, insect resistant genes, nutrition enhancing genes. OMIM database, reference genome sequence, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases, RNAseq databases and SNP database.

Unit 3 **9 Lectures**

Transcriptome Analysis: 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). Role of SNP in Pharmacogenomics. Gene prediction using Machine learning toolsviz. Neural network, etc.

Unit 4 **9 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-dimensionalfluorescence difference in-gel electrophoresis (DIGE), Blue native PAGE (BN-PAGE), gel free proteomics methods.

Unit 5 **9 Lectures**

Protein-protein interactions and quantitative proteomics: Characterization of interaction clusters using two-hybrid systems, and phage display. Protein MS applications – identifying unknown proteins by peptide mass fingerprinting; de novo sequencing of peptides from fragment ion spectra obtained by tandem MS.

Text Books:

1. Brown T. A. 2007, Genomes 3. Garland Science Publishing, New York.
2. Dunham, I., 2003. Genome Mapping and sequencing. Horizon Scientific
3. Discovering Genomics, Proteomics and Bioinformatics 2nd edition - by A. Malcolm Campbell and Laurie J. Heyer. by Cold Spring Harbor Laboratory Press 2006.
4. Bioinformatics and Functional Genomics (3rd Ed.) by Pevsner, J., John Wiley and Sons, New Jersey, USA. 2015

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: Sequence and Genome Analysis by Mount, D., Cold Spring Harbor Laboratory Press, New York. 2004

COURSE OUTCOME: *The students will be able to explain the genomic and proteomic strategies and apply bioinformatics tools for the same.*

BINF422- BIOINFORMATICS: SEQUENCE ANALYSIS

COURSE OBJECTIVES: *To introduce the methods of Sequence analyses and their applications in Bioinformatics*

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

Unit 1 **9 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. Repeats: Tandem and Interspersed repeat finding, Motifs, consensus, position weight matrices. **Secondary structure prediction:** Algorithms viz. Chou Fasman, GOR methods; analysis and measuring the accuracy using Q3, Mathew's correlation coefficient Identification/comparison with DSSP and STRIDE methods.

Unit 2 **9 lectures**

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). **Sequence similarity Network** - Cytoscape.

Unit 3 **9 lectures**

Comparative Genomics: Basic concepts, Applications of Comparative Genomics: Identifications of Protein coding genes and non-coding genes, Regulatory Regions, Virulence factors / Pathogenicity islands; Reconstruction of metabolic pathways, Ensemble comparative genomics resources.

Unit 4 **9 lectures**

Sequence patterns and profiles: Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches.
Algorithms for derivation and searching sequence patterns: MEME, PHI-BLAST, SCanProsite and PRATT. Algorithms for generation of sequence profiles: Profile Analysis method of Gribskov, HMMer, PSI-BLAST.

Unit 5 **9 lectures**

Molecular Phylogenetics: Phylogenetics Basics: Molecular Evolution and Molecular Phylogenetics, Terminology, Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation; Phylogenetic Tree Construction Methods and Programs**:** Distance-Based Methods, Character-Based Methods, Phylogenetic Tree Evaluation, Phylogenetic Programs.

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. Advances in Genomic Sequence Analysis by Laura Elnitski.,National Institutes of Health, USA.2011

Reference Books:

1. Introduction to Bioinformatics (1st Edition) by Arthur M. Lesk, Oxford University Press, 2002.
2. Bioinformatics in the Post-Genomic Era by Jeffrey Augen, Addison-Wesley Publisher, 2004.
3. 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
4. Essential Bioinformatics by Jin xiong.,Combrridge University press,New York.2006

COURSE OUTCOME: *Students will be trained to perform genomic evolutionary analyses as well as structure modeling from protein sequences.*

BINF 423 – PROGRAMMING IN JAVA

COURSE OBJECTIVES: *To understand and implement OOPs concept through JAVA programming language and to learn applet programming.*

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

Unit 1 **8 lectures**

Java Basics: Importance and features of JAVA, Lexical elements of JAVA, Data types and Control structure, Program structure, Arrays, Command line input handling, OOPS, String Handling.

Unit 2 **9 lectures**

Package, Exception Handling and File Handling: Package concept, working with util package, Built-in Exceptions, Exception Handling, User Defined Exception, Streams in Java: FileInputStream, FileOutputStream, DataInputStream, DataOutputStream, Serialization.

Unit 3 **9 lectures**

JDBC and Applets: JDBC, Steps to connect database, Classes and Methods for Database connectivity and Data Manipulation, Applets: Importance of applets, Steps to build an applet, Applet class methods, applet life cycle, creation and execution of applets, Graphics class methods.

Unit 4 **9 lectures**

AWT and Threads: AWT - Concept, components, methods. **Threads -** Thread creation and methods for animation, Event Delegation Model: Concept, Components (Events, Listeners, Event Adapters and containers), Layouts.

Unit 5 **9 lectures**

Biojava: Concepts, Installation, Symbols &SymbolList, DNATools, MotifTools, RNATools, DNA to RNA conversion, Translation of DNA sequence to Protein sequence, proteomics classes: Calculate Mass and isoelectric point, Sequence I/O basics, Parsing, remote pdb file access (programming code demonstration).

Text Books :

1. Herbert Schildt, 2017. Java – A Beginner's Guide, 7th Edition, MCGRAW HILL.
2. Andreas Prlic, Andrew Yates, Spencer E. Bliven, et al., BioJava: on open-source framework for bioinformatics in 2012. Bioinformatics. 28(20): 2693-2695. https://www.biojava.org

Reference Books :

1. Herbert Schildt, 2018, JAVA: The complete reference, 11th Edition, TATA MCGRAW HILL Edition, Kindle Edition.
2. Yakov Fain. 2015, Java Programming: 24 Hour Trainer, 2nd Edition, Wiley publication.
3. Barry Burd. 2014. Java FOR Dummies. 6th Edition, Wiley & Sons.

COURSE OUTCOME: *To develop software tools and distributed packages for various sequence manipulation and analysis.*

BINF 424 - DATABASE MANAGEMENT SYSTEM

COURSE OBJECTIVES: *To understand database concepts and data manipulation queries.*

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

Unit 1 **9 lectures**

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

Unit 2 **9 lectures**

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

Unit 3 **9 lectures**

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

Unit 4 **9 lectures**

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

Unit 5 **9 lectures**

Concurrency control techniques & Information retrieval: Transactions: Properties of transactions: Concurrency problems, Serialisability and Locking techniques, Granularity of Data Items – Database System Architecture and Information retrieval: Centralized and Client-Server Architecture.

Text Books:

1. Database System Concepts (7th Ed.) by Silberschatz, A., Korth, H.F. and Sudarshan, S., 2019, McGraw Hill Publishers.
2. Database Management Systems(3rd edition), Raghu Ramakrishnan, Johannes Gehrke, 2014, McGraw-Hill.

Reference books:

1. An Introduction to Database Systems (8th Ed.) by Date, C.J., Addison Wesley Publishers. 2003
2. Fundamentals of Database Systems (7th Ed.) by Elmasri and Navathe, Addison Wesley Publishers. 2015
3. Principles of Database Systems (2nd Ed.) by Ullman, J. D., Galgotia Publications. 2001

COURSE OUTCOME: *Able to write database queries to analyze the data*

BINF 425 - FUNDAMENTALS OF ALGORITHMS

COURSE OBJECTIVES: *To understand the concept of algorithm to be applied usingdifferent techniques and to know the asymptotic performance of algorithms. Demonstration of algorithms using different kinds of data structures.*

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

Unit 1 **9 lectures**

Computing Algorithms: Algorithms in Computing, Analyzing algorithms, Designing algorithms, Asymptotic notation, Standard notations, Big 'O' notations, Time and space complexity of algorithms and common functions.

Unit 2 **9 lectures**

Sorting, Searching & Strings Matching: Sorting: Bubble sort, Insertion sort, Selection sort, Merge Sort, Quick Sort**,** External sort: K-way merge sort, balanced merge sort, Searching: Binary Search, Fibonacci Search. String Matching: Naïve algorithm, Boyer Moorealgorithm.

Unit 3 **9 lectures**

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

Unit 4 **9 lectures**

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

Unit 5 **9 lectures**

Algorithm Design and Analysis: The substitution method, The iteration method, Divide and Conquer, Greedy Algorithms, Dynamic Programming: Traveling Sales Person Problem Backtracking Algorithms: 8-queens Problem.

Text Books:

1. Fundamentals of Algorithms by E. Horowitz and S. Sahani., Galgotia Book source Pvt. Ltd. 1999.
2. Introduction to Algorithms, Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L.; Stein, Clifford (2009) [1990], MIT Press and McGraw-Hill, 2016.

Reference Books:

1. Data Structures by Seymour Lipschutz., Tata Mc-Graw-Hill publication. 2007
2. Introduction to Algorithms (3rd Ed.) by T .H. Cormen, C. E. Leiserson, R .L. Rivest., The MIT Press. 2007

COURSE OUTCOME: *To employ the important algorithmic design paradigms and methods of analysis.*

BINF 426 – BIOSTATISTICS

COURSE OBJECTIVES: *To understand the key concepts of biostatistics, and use them to analyze biological data and draw the inferences for analyzed data*

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

Unit I **6 lectures**

Numerical descriptive techniques: Measures of central tendency-mean, median, mode, Partition values-quartiles, deciles, percentiles, Measure of dispersion, Moments, Skewness, Kurtosis.

Unit II **6 lectures**

Correlation and Regression: Principle of least squares, scatter diagram, correlation, covariance, correlation coefficient, properties of correlation coefficient, regression, properties of linear regression, rank correlation, multiple correlation, application of correlation and regression in Biology.

Unit III **6 lectures**

Probability Theory: Classical and modern definition of probability, Sample space andevents, independent events, mutually exclusive events, axioms of probability, conditional probability, additional and multiplication theorem of probability, Baye's theorem and its application in Biology, Maximum likelihood method

Unit IV **6 lectures**

Sampling Theory: Objective of sampling, Sampling error, Methods of sampling, Sampling distribution, Sampling distribution of sample mean and sample proportion, Standard error.

Unit V **6 lectures**

Probability Distribution: Bernoulli's trial, Binomial distribution, Poisson distribution, Poisson approximation to Binomial distribution, Normal and Standard normal distribution, Normal approximation to Binomial (Poisson), Student's t distribution, Chi-square distribution, F-distribution.

Text Books:

1. Biostatistics (9th Ed.), Wayne W. Daniel, John Wiley & Sons, 2018.
2. Biostatistical Analysis (5^{th} edition), Jerrold H. Zar, Pearson, 2018

Reference Books:

1. Statistical Methods (1^{st} Ed.), N. G. Das, Tata McGraw-Hill, 2017.
2. Fundamentals of Biostatistics (6th Ed.), Bernard Rosner, Thomson Brooks/Cole, 2015.

COURSE OUTCOME

Have better understanding about the principles of biostatistics
Ability to perform and interpret statistical analyses with real biological data

BINF 427 - MICROSCOPIC TECHNIQUES FOR IMAGE PROCESSING

COURSE OBJECTIVES: *To impart knowledge on instrumentation and sample handling methods for several microscopic techniques.*

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

Unit 1 **6 lectures**

Transmission electron microscopy TEM: Wave nature of electrons – Electromagneticlenses – Basic components of Transmission Electron Microscope – Alignment of TEM – Major operational modes of TEM.

Unit 2 **6 lectures**

Scanning electron microscopy: Basic systems of the SEM – Contrast and three-dimensionality of the SEM image – Stereo imaging with the SEM**.**

Unit 3 **8 lectures**

Specimen preparation for EM: *TEM:* Specimen preparation for TEM – Fixation – Washing – Dehydration – Embedding – Specimen staining for TEM – Positive staining and negative staining – Metal shadowing techniques – CryoEM - Applications.

Ultramicrotomy: Shaping the specimen block – Types of ultramicrotome knives – EM grids – Support films for grids – Ultramicrotome and section processing.
SEM: Surface cleaning – Rinsing and dehydration – Specimen drying techniques – Specimen fracture procedures – Replication procedures – Specimen mounting – Specimen coating for conductivity - Applications.

Unit 4 **5lectures**

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

Unit 5 **5 lectures**

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

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

Text Book:

1. Electron Microscopy: Principles and techniques for biologists by John J Bozzola, and Lonnie Dee Russell., Jones & Bartlett Learning. 1999.
2. Handbook of Biological Confocal Microscopy, by Pawley, J.B., Springer-Verlag. 2006.

Reference Books:

1. Principles and Techniques of Electron Microscopy: Biological Applications by M.A.Hayat., Cambridge University Press. 2000.

COURSE OUTCOME: *The students will possess theoretical knowledge in handling the several microscopic techniques for imaging biological samples.*

BINF 428- ANIMAL CELL CULTURE AND TECHNOLOGY

COURSE OBJECTIVES: *It provides insights into the application of tissue culture on animal cells. The course will be a short primer to understand how 'animal cell culture technologies' have strengthened the bio-medical research from basic research to the modern drug discovery.*

Total Credits: 2 **30 Hrs***

Unit-1 6 **lectures**

Structure and Organization of Animal Cell: Animal Cell Culture: Historical Background Basic techniques of mammalian cell culture in vitro. Cell lines and primary and established cell line culture.

Unit-2 6 **lectures**

Type of culture Growth media: Introduction to the balance salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Serum and protein free defined media and their application. Maintenance of animal cell culture.

Unit-3 6 **lectures**

Maintenance of animal cell culture: Trypsinization of monolayer and measurement of viability and cytotoxicity. Biology and characterization of cultured cells, measuring parameters of growth, flow cytometry. Measurement of cell death, apoptosis mechanism and significance.

Unit-4 6 **lectures**

Basic techniques of mammalian cell culture: Disaggregation of tissue and primary culture; cell separation. Scaling-up of animal cell culture, Cell Synchronization. Cell transformation, transfection and Application of cell culture- application of animal cell culture for in vitro testing of drugs;. Tissue and Organ culture. Production and use of artificial tissue and organs-Skin, Liver and Pancreas.

Unit-5 6 **lectures**

Stem cells- Properties of stem cell: Stem cells- Properties of stem cell; Types of stem cell: Embryonic stem cell, Adult stem cells; Stem Cells in the epithelium of the small intestine and colon, and their applications. Cell culture based vaccines. Cell for adaptive and cellular immunotherapy; bone marrow transplantation-advantages and disadvantages.

Text Books:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6^{th} Edition) R.Ian Forshney, (Wiley-Liss)-2010
2. Animal cell culture techniques. Ed. Marti Clynes.(Springer)-1998
3. Molecular and Cellular methods in Biology and Medicine, P.B. Kaufman, W. Wu, D. Kim and L. J. Cseke. CRC Press, Florida- 2011.

Reference Books:

1. Animal cell culture-A Practical Approach, Ed.john R.W. Mesters, Oxford (IRL Press)-2000.
2. Stem cells in regenerative medicine by Audet (Springer)-2009.
3. Cell and tissue reaction engineering by Eibi (Springer)-2009.

COURSE OUTCOME: *For biologists and non-biologists, it will be an informal way to demystify the intriguing routes of biomedical research where cell culture is a very 'potent tool'.*

BINF 459 - LAB - PROGRAMMING IN JAVA

COURSE OBJECTIVES: *To implement OOPs concepts, Java coding and to design graphical user interface.*

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. Interface and abstract class implementation
7. Working with util package
8. Exception handling
9. Reading and writing files.
10. JDBC implementation
11. Applets
12. Graphics
13. Animation and Threads.
14. Managing Simple Events and Interactivity.

COURSE OUTCOME: *To design application tools for biological sequence manipulation*

BINF 457 - LAB- DATABASE MANAGEMENT SYSTEM

COURSE OBJECTIVES: *To practice SQL queries for database management.*

Total Credits: 1

Structured Query Language

1. **Creating a Database/Table**
    1. Creating a Database
    2. Creating a Table
    3. Specifying Relational Data Types
    4. Specifying Constraints
    5. Creating Indexes

2. **Table and Record Handling**
    1. INSERT statement
    2. Using SELECT and INSERT together
    3. DELETE, UPDATE, TRUNCATE statements
    4. DROP, ALTER statements

3. **Retrieving Data from a Database**
    1. The SELECT statement
    2. Using the WHERE clause
    3. Using Logical Operators in the WHERE clause
    4. Using IN, BETWEEN, LIKE, ORDER BY, GROUP BY and HAVING Clause
    5. Using Functions
    6. Combining Tables Using JOINS
    7. Subqueries

4. **Database Management**
    1. Creating Views
    2. Creating Column Aliases
    3. Creating Database Users
    4. Using GRANT and REVOKE

COURSE OUTCOME: *Students can create, query and maintain SQL databases.*

BINF 458 - LAB - BIOSEQUENCE ANALYSIS

COURSE OBJECTIVES: *To make the students familiarized with the techniques used in Bioinformatics sequence analysis and their applications*

Total Credits: 1

Exercises:

1. Sequence Databases: EMBOSS, NCBI ToolKit, ExPASy 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. Binding site identification

7. 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

8. Protein motif and domain analysis:
   a. MEME/MAST
   b. eMotif
   c. InterproScan
   d. ProSite
   e. ProDom
   f. Pfam
9. Phylogenetic analysis – Mega, Paup, phylip

COURSE OUTCOME: *Students can understand the information's available in Bioinformatics databases and their applications in research*

SEM-III

BINF 511 - STRUCTURAL BIOLOGY

COURSE OBJECTIVES: *The main objective of this course is to make the students to thorough understanding of structural biology of biological macromolecules.*

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

Unit 1 **9 Lectures**

Macromolecules: DNA and RNA- types of base pairing – Watson-Crick and Hoogstein; types of double helices A, B, Z and their geometrical as well as structural features; structural and geometrical parameters of each form and their comparison; various types of interactions of DNA with proteins, small molecules. RNA secondary and tertiary structures, t-RNA tertiary structure. **Proteins**: Principles of protein structure; anatomy of proteins – Hierarchical organization of protein structure – Primary. Secondary, Super secondary, Tertiary and Quaternary structure; Ramachandran Map.

Unit 2 **9 Lectures**

Protein structure determination techniques: X-ray crystallography Electromagnetic radiation, origin of X-rays, diffraction basics, Bragg's Law , phase problem, different methods for solving phase problem ,**NMR techniques**, Nuclear Magnetic Resonance: Chemical Shift, Coupling constant, spin-spin relaxation, spin-lattice relaxation, COSY, NOESY and NOE, **cryo-electron microscopy.**

Unit 3 **9 Lectures**

Structural modeling- Homology modeling, Template recognition and initial alignment, Alignment correction, Backbone generation, Loop modelling, Side-chain modelling, Model optimization, Model validation, Threading, ab initio method, Protein-protein interaction ,Protein-ligand interaction, Protein-DNA interaction, Prediction of binding cavities.

Unit 4 **9 Lectures**

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

Unit 5 **9 Lectures**

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

Text Books:

1. Introduction to protein structure. By C Branden and J Tooze, New York. 2 editions (January 3, 1999).
2. Textbook of Structural Biology, by Anders Liljas, Lars Liljas, Jure Piskur, Göran Lindblom, Poul Nissen, and Morten Kjeldgaard, 2nd Edition edition (January 4, 2017.
3. Protein Structures and molecular properties: By T E Creighton, W H Freeman, New York. Second edition (August 15, 1992).

Reference Books:

1. Crystals, X-rays and Proteins: Comprehensive Protein Crystallography 1st Edition, Kindle Edition by Dennis Sherwood and Jon Cooper, 2011
2. Fundamentals of Crystallography by Giacovazzo Carmelo, Third Edition 2011.
3. Principles of Protein X-ray Crystallography by Drenth Jan, Third edition, 2007
4. Introduction to Crystallography by Donald E. Sands, 1st Edition, 1994

COURSE OUTCOME: *Students gained the knowledge of structural biology of biological macromolecules.*

BINF 512 - MOLECULAR MODELING AND DRUG DESIGN

***COURSE OBJECTIVES**: Aims to provide students with the knowledge and ability to create and interpret force fields, energy minimization models, molecular dynamics simulation techniques and drug design approaches*

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

Unit 1 **9 Lectures**

Force field parameters and models: Introduction:- Hooks law, Harmonic Oscillator Model for Molecules, Morse Potential and comparison with Harmonic Potential, Intra- and Inter-molecular forces and energies, Potentials: Lennard-Jones, Truncated Lennard-jones, Exponential-6, Ionic and Polar potentials. Types of Force Fields: Biomolecular force fields (AMBER, GROMOS, etc.), Molecular Mechanics potentials for small organic molecules (MM series), second generation force fields (UFF, CFF and MMFF)

Unit 2 **9 Lectures**

Potential Energy Surface and Energy Minimization: PES and features, Convergence Criteria and Characterization. Minimization:- multivariable minimization Algorithms, level Sets and Curves, Gradients, Minimization Criteria, Unidirectional Search, Finding Minimum Point, First order methods:- Steepest Descent and Conjugate Gradient Methods.

Unit 3 **9 Lectures**

Molecular Dynamics Simulation: Introduction, Newtonian dynamics, Integrators- Leapfrog and Verlet algorithm, Radial distribution functions, Pair Correlation function, Potential truncation and shifted-force potentials, solvation and models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations.

Unit 4 **6 Lecture**

Basis of drug action: How drugs work - Pharmacokinetics (ADME) and pharmacodynamics basis of drug action. **New drug discovery process** - Target identification and validation, lead identification and optimization. Pre-clinical and clinical testing of new drugs.

Unit 5 **12 Lectures**

Drug Design approaches:- Structure based drug design: Prediction and validation of 3D structure of proteins using homology modeling for docking**.** Basis of Docking (pose prediction and scoring algorithms) and its application in lead identification and optimization, De Novo Drug Design (Fragment Placements, Connection Methods, Sequential Grow), Virtual screening strategies for lead identification. **Ligand based drug design -** Pharmacophore generation (3D database searching, conformation searches, deriving and using 3D Pharmacophore, constrained systematic search, Genetic Algorithm, clique detection techniques, maximum likelihood method) and application for virtual screening. Introduction to QSAR, descriptors used in QSAR study, model building (regression Analysis, Partial Least Squares (PLS), Principle Components Analysis (PCA)), model validation methods and applications of QSAR.

Text Books:

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

3. Computational Drug Design: A Guide for Computational and Medicinal Chemists, by David C. Young, Wiley, 2009.

Reference Books:

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., Springer-Verlag 2000
3. Computational Medicinal Chemistry for Drug Discovery, edited by Patrick Bultinck., Hans De Winter, Wilfried Langenaeker, Jan P. Tollenare, CRC press, 2003.
4. The art of molecular dynamics simulation, second edition by D. C. Rapaport, Cambridge University Press, 2004
5. Homology Modeling Methods and Protocols by Andrew J.W. Orry., University of California,USA.2012.

COURSE OUTCOME: *Students could understand the theories in macromolecular simulations and perform research work in the area of computational drug design.*

BINF 513 - PROGRAMMING IN PERL

COURSE OBJECTIVES: *To introduce the fundamentals of Perl programming language to the student. To familiarize with Perl modules and to write scripts for manipulating/processing genomic and proteomic data*

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

Unit 1 **9 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, Using Hashes for the Genetic Code, Gene Expression Data Using Hashes.

Unit 2 **9 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 **9 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, Opening and Closing a Directory, Reading aDirectory, File and Directory Manipulation.

Unit 4 **8 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 **10 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. Mastering Perl for Bioinformatics (1st Ed.), J. Tisdall, O'Reilly, 2010
2. Mastering Perl: Creating Professional Programs with Perl (2nd Ed.), Brian d foy, O'Reilly, 2014

Reference Books :

1. Programming Perl (3rd Ed), L.Wall, T. Christiansen and J. Orwant, O'Reilly, 2007
2. Beginning Perl for Bioinformatics (1st Ed.), J. Tisdall, O'Reilly, 2004

COURSE OUTCOME

Able to write Perl scripts for processing biological data
Able to use toolkit of Perl modules for various bioinformatics applications

BINF 514 - SYSTEMS BIOLOGY

COURSE OBJECTIVES: *The main goal of this course is to help students in learning the basic concepts and computational methods involved in the computational modelling of the biological systems.*

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

Unit 1 **9 lectures**

Introduction & Biological Networks: Systems Biology: Emergent property, Applications in health and diseases. Microarrays and its applications in systems biology. Connectivity maps (CMap) and Library of Integrated Network-based Cellular Signatures (LINCS) - definition and its uses. Biological Networks: Degree distribution, Clustering coefficient, Random networks, Scale-free networks, small-world effect.

Unit 2 **9 lectures**

Simulation of pathways: Metabolic network, 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 3D).

Unit 3 **9 lectures**

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

Robustness and optimality in Biological complex systems: Biological Robustness: System control, modularity, decoupling. Optimal design of gene circuits I- cost and benefit: gene circuits II- selection of regulation. Stochasticity in gene expression.

Unit 4 **9 lectures**

Databases and softwares for Systems Biology: Introduction- databases: KEGG, EMP, MetaCyc. Expression databases and other databases related to systems biology. Cytoscape, visANT & CellDesigner.

Unit 5 **9 lectures**

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

Text Books:

1. Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall/CRC, 2007.
2. Synthetic Biology: A Primer by P.S. Freemont & R.I. Kitney, Imperial College Press, 2012.

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.
3. Networks – an Introduction, Mark Newman, Oxford University Press, 2010.

COURSE OUTCOME: *The student will have a system-level understanding of the biological systems. He/she will be able to develop and analyse the properties of in silico models of gene-gene interactions and protein-protein interactions.*

BINF 515 - DATA MINING AND MACHINE LEARNING

COURSE OBJECTIVES: *To learn various mining techniques used to analyses huge biological data to find the hidden patterns.*

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

Unit 1 **9 lectures**

Introduction: Introduction – History - Importance of Data Mining - Types of data gathered - Uses of Data Mining - Data Mining Techniques - Data Warehouses -TransactionalDatabases - Advance Database Systems and Applications - Data Mining Architecture - Data Mining Functionalities - Classification of Data Mining Systems - Major issues in DataMining - Data Mining Applications (Bioinformatics & General) - Advantages and Disadvantages.

Unit 2 **9 lectures**

Primitives: Why Data Mining Primitives? - Primitive specifications (Task relevant data, Kind of knowledge to be mined, Background knowledge, Pattern Interesting Measures,Visualization of discovered patterns) - Data Mining Query Language – Syntax and example for each primitive specifications.

Unit 3 **9 lectures**

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

Unit 4 **9 lectures**

Classification and Prediction: Classification and Prediction – Issues in Data preparation for classification and Prediction - Classification algorithms - Classification by Decision Tree Induction - Classification by Naïve Bayes – Classification by Backpropagation.

Unit 5 **9 lectures**

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

Text Books:

1. Pang-Ning Tan, Michael Steinbach and Vipin Kumar, 2016, Introduction to Data Mining, Pearson India Education Services Pvt. Ltd, ISBN: 978-93-3257-140-2.
2. Len Trigg et al, 2010, Weka-A Machine Learning Workbench for Data Mining, DOI: 10.1007/978-0-387-09823-4_66

Reference Books:

1. Sumeet Dua, Pradeep Chowriappa. 2012. Data Mining for Bioinformatics. First edition. CRC Press. ISBN 9780849328015.
2. Jiawei Hen, Micheline Kambler , 2006, Data Mining Concepts and Techniques –, Academic Press Morgan Kaufman Publishers.
3. Yonghua Cen and Yanchang Zhao, 2013, Data Mining Applications with R, Academic Press, ISBN: 9780124115118.

COURSE OUTCOME: *Able to handle the huge heterogeneous biological data sets by applying different mining algorithms and techniques.*

BINF 517 – SPECTROSCOPY IN BIOLOGY

COURSE OBJECTIVES : *A course that is meant for teaching various spectroscopic tools available to extract useful information in respect of biological samples.*

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

Unit 1 **6 lectures**

UV- Visible spectroscopy: Absorption laws - calculations involving Beer - lambert's law - instrumentation – photo colorimeter and spectrophotometer - block diagrams with description of components - theory - types of electronic transitions - chromophore and auxochromes - absorption bands and intensity - factors governing absorption maximum and intensity Fluorescence spectroscopy.

Unit 2 **6 lectures**

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

Unit 3 **6 lectures**

Raman spectroscopy: Raleigh and Raman scattering - Stoke's and anti Stokes lines - instrumentation - block diagram - differences between IR and Raman spectroscopy - mutual exclusion principle - applications - structural diagnosis.

Unit 4 **6 lectures**

Nuclear Magnetic Resonance Spectroscopy: Nuclear spin magnetic moment, Interaction of nuclear magnet with external magnetic field, NMR spectrometer, relaxation and dynamic processes, chemical shift, coupling constants in ^{1}H, ^{13}C and ^{31}P NMR spectra; application of NMR spectroscopy for structure elucidation of simple biomolecules. Heteronuclear NMR experiments.

Unit 5 **6 lectures**

Electron Spin Resonance Spectroscopy: Electron spin and Magnetic moment, Resonance condition in ESR and significance of 'g' value, applications of ESR of (i) transition metal ions (ii) free radicals and (iii) spin labels in Biology. Introduction to Pulsed EPR.

Text books:

1. Fundamentals of molecular spectroscopy by C. N. Banwell., McGraw-Hill.1983
2. Modern Spectroscopy (Fourth Edition) by J. Michael Hollas (2004) John Wiley & Sons.

Reference Books:

1. Molecular spectroscopy by I. N. Levins, Wiley Interscience. 1975
2. Electron Spin Resonance : Elementary Theory and Practical Applications by John Wertz Springer (1986)
3. Nuclear Magnetic Resonance Ed. Hans-Ferdinand Linskens and F John Springer (1986)
4. Introduction to molecular spectroscopy by G. M. Barrow., McGraw-Hill.1962

COURSE OUTCOME: *The students will be introduced to the working principles and applications of various common spectroscopic techniques.*

BINF 518 - PLANT SYSTEM BIOLOGY

COURSE OBJECTIVES: *Students will learn about the general morphology, anatomy and physiology of vascular plants. It would enable to acquire knowledge on the resources needed to complete their life cycle and the relationships between the structure and function in co-ordinating the process of development and tissue organization. It will also ensure for learning the advanced techniques employed in plant genomics and proteomics along with editing technologies for prosperous growth and yield of plants*.

Total credits: 2 **Total: 30Hrs***

Unit I: 6 **Lectures**

Plant vascular development: Basis of Growth, Organ development, role of Plant hormones, oriented cell divisions in plants

Unit II: **6 Lectures**

Plant growth: lateral growth, seasonal growth, wood formation, Photo morphogenesis, cell cycle and control.

Unit III: **6 Lectures**

Molecular mechanism in plant adaptation: plant secondary metabolism, Biosynthetic and regulatory pathway. Plant defensins- defensive phenyl propanoids, jasmonates, aromatic alkaloids. Abiotic stress tolerance-induced peptides, small signaling peptides and role of small RNAs.

Unit IV: **6 Lectures**

Plant interactions: Modes- Competitive, Non-competitive and Complementary. Types- plant to plant interactions, plant to microbe interactions, plant to fungus interactions, plant to pollinators interactions.

Unit V: **6 Lectures**

Plant genome editing : gene editing, ZFN, TALEN and CRISPR. Network biology - data integration, comparative genomics- gene prediction and annotation using Virtual Plant, Genevestigator, Mapman, Cytoscape.

Text Books:

1. C. Neal Stewart Jr. (2016) Plant biotechnology and genetics principles, techniques, and applications- John Wiley & Sons Inc.
2. Gloria Coruzzi, Rodrigo Gutirrez (2009) Plant systems Biology Annual Plant Reviews, Volume 35 , Wiley Blackwell
3. HeribertHert (2009) Plant Stress Physiology From genomics to system biology, Wiley Blackwell

Reference Books:

1. Taiz &Zeiger Plant Physiology 5 ed. Sinauer Associates. 2010
2. Rob W. Brooker, Plant–plant interactions and environmental change, New Phytologist, 71 (2): 271-84.2006.

COURSE OUTCOME: *At the end of the course, the students will be able to explain the basic concepts of plant system biology. It will help the student to understand the molecular basis of growth, development and adaptation of plant systems*.

BINF 519 - INTRODUCTION TO BIOPHYSICS

COURSE OBJECTIVES: *The course is intended to introduce some of the interesting concepts of Biophysics to emphasize the applications of physics and chemistry on biological systems*

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

Unit 1 **6 Lectures**

Biological Polymers: Physicochemical properties of water, Molecular structure, Nature of hydrophobic interactions, Water Structure. **Small-Molecule Solutes**: Hydrophiles, Hydrophobes, Large Hydrophobic Solutes and Surfaces, Aqueous Environment of the Cell, State of water in bio- structures & its significance, Polysaccharides – primary structure – levels of structure in -polysaccharide – Association formed among different macromolecule types – lipid in biological membranes – Protein lipid interactions. Protein Hydration- Nonspecific Effects, The Hydration Shell- Conformation analysis and forces that determine nucleic acid structure

Unit 2 **6 Lectures**

Reaction kinetics: Reaction kinetics (reaction order). Determination of reaction order, molecularity of reaction. Complex reaction, reactions in solution- importance of ligand interaction- ligand equilibria – kinetics of ligand interaction – simple Bimolecular reaction – simple Michaelis – Menten mechanism – multiple intermediates – steady state kinetics - **Redox potential:** Oxidation –Reduction, redox potential and Nernst equation, Gibbs energy of formation and activity.

Unit 3 **6 Lectures**

Bioenergetics: Concept of free energy, types of Bioenergetics reactions endergonic, exergonic reactions and activation energy), Relationship between free energy, enthalpy and entropy- Thermodynamics III law and Gibbs energy, chemical potential molar Gibbs energy and equilibrium - Chemiosmotic energy transduction: fundamentals. Examples of redox potential in biological system: The Respiratory Chain, Photosynthetic reaction. Classification; biological significances of ATP and cyclic AMP

Unit 4 **6 Lectures**

Vibrational motions: Simple harmonic oscillator: classical theory and potential energy; Simple harmonic oscillator: quantum theory, solving Schrödinger's equation for harmonic oscillator, Transitions and forbidden region, vibrational spectra in Biomolecules and applications

Unit 5 **6 Lectures**

Membrane biophysics: Membrane potentials (energetics of transport across membranes), transporters and channels: classification of ion transport, Bilayer mediated, protein-catalysed transport, swelling and co-ordinated movement across membranes. Energetic of transport across membranes theories, Goldman–Hodgkin–Katz Model, Hodgkin–Huxley Model, Cooperatively in Ion Channel Kinetics

Text Books:

1. Biophysical chemistry by James P. Allen, Wiley-Blackwell, A John Wiley & Sons, Ltd., Publications, 2008
2. Theoretical Molecular Biophysics by Scherer, Philipp O.J., Fischer, Sighart F. Springer-Verlag Berlin Heidelberg, 2017

3. Bioenergetics 4th edition David Nicholls, Academic Press
4. Physical Chemistry for Life Sciences by Barrow C, MC-Grow Hill
5. Biophysical Chemistry by Bloomfield V A and Harrington R E, W A Freeman and Co.
6. Aspects of Biophysics, Hughe S W, John Willy and Sons.
7. Introduction of Biophysics by Pranab Kumar Banargy, S Chand and Co.
8. Biochemistry by Stryer L, W A Freeman and Co.

Reference Books:

1. Essentials of Biophysics by P Narayanan, New Age International Publishers, 2007
2. Biophysical Chemistry Part I, II and III by Cantor and Schimmel, W.H. Freeman and company.2004

COURSE OUTCOME: *The students will be able to understand some of the biomolecular functions from the perspectives of Physics and Chemistry*

BINF 520 – RESEARCH METHODOLOGY AND FINISHING SCHOOL

COURSE OBJECTIVES: *To provide overview of how to identify research problem and conduct research.*

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

Unit 1 **9 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; Features of good research design; Data Collection - Data Analysis - Interpretation of results and Report writing.

Unit 2 **10 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) and publication ethics

Unit 3 **9 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 **8 Lectures**

Poster Presentation: Elements and Significance of poster presentations- Planning and designinga poster- Individual Poster presentation (Students select a research project/topic and prepare posters followed by a Q&A sessions).

Unit 5 **9 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-lifebalance, Culture and cultural ethos - cultural diversity - diversity in organizations.

Text Books:

1. Experimental design for the life sciences, 4th edition, by Ruxton, G.D. and Colegrave, N. Oxford University Press, Oxford, 2017.
2. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (4th Ed.) by J.R. Matthews and R.W. Matthews, Cambridge University Press. 2014.

References Books:

1. Scientific Writing 2.0: A Reader and Writer's Guide, by Jean Luc- Lebrun, World Scientific Publishing Company; 2nd Revised ed., 2011.

2. Writing and Presenting Scientific Papers, 2nd Edition by Birgitta Malmfors, Phil Garnsworthy and Michel Grossman, Nottingham University Press, 2004, Viva Books Pvt. Ltd. 2011.

COURSE OUTCOME: *Students can understand the basics of how to design, conduct research, analyze and communicate the results to research community. Also team work ethos and stress management strategies would help to cope-up with their day-to-day life in a competitive world.*

BINF 551 - LAB - STRUCTURAL BIOLOGY

COURSE OBJECTIVES: *The main objective of the course is to train the students how to determine the small molecule structure through X-ray crystallography*

Total Credits: 1

1. Advanced Visualization Software and 3D representations.
2. Small Molecule Structure determination
    a) Structure Solution: SHELXS
    b) Structure Refinement: SHELXL
3. Thermal Ellipsoid Plot:
    a) ORTEP
4. Structure analysis
    a) PARST
    b) Platon
    c) Mercury
5. Comparative structure alignment and analysis using three dimensional structures of protein and nucleic acids.
    A) DALI
6. Structure Validation
    Procheck, WHATIF, VERIFY 3D
7. Exploration of CCP4 for macromolecular crystallography

COURSE OUTCOME: *Students gained the knowledge of how to solve the small molecule structure through X-ray crystallography method.*

BINF 552 - LAB - MOLECULAR MODELING AND DRUG DESIGN

COURSE OBJECTIVES: *Aims to train students with technical skills to perform molecular dynamics simulations and drug design aspects*

Total Credits: 1

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. Homology modeling of protein 3D structure
   - Model building using Modeller
   - Model validation

5. Binding Site Identification
   - Different approaches for binding site identification
   - Tools - Cast-P, POCASA, 3D ligand site, Metapocket, Ghecom

6. Structure based Drug design
   - Molecular docking using AutoDock
   - Virtual Screening using AutoDock Vina

7. Molecular Dynamics Simulation
   - Protein dynamics using Gromacs
   - Protein-ligand complex MD simulation

COURSE OUTCOME: *Students will be skilled to perform macromolecular simulations and drug design which will be useful for their research/project work*

BINF 553 LAB - PROGRAMMING IN PERL

COURSE OBJECTIVES: *To provide a practical introduction step-by-step to develop Perl scripts for biological data handling*

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

COURSE OUTCOME: *Able to design tools and web pages for various biological applications*

SEM-IV

BINF 521 - BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

***COURSE OBJECTIVES**: To impart knowledge on manufacturing, ethical and safe handling of various biotechnologically produced health and agricultural products as well as on intellectual properties.*

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

Unit 1 **9 Lectures**

Regulatory Procedures: Good laboratory practice, Good manufacturing practice and National and International regulations - Regulations for recombinant DNA research andmanufacturing process - Bio-safety and Bioethics - Regulations for clinical trials, Documentation and Compliance, in India and selected countries - Rules for import and export of biological materials.

Unit 2 **9 Lectures**

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

Unit 3 **9 Lectures**

IPR: Definition - Forms of IPR Protection, WTO - Definition — Functions- International treaties for IPR Protection.

Unit 4 **9 Lectures**

Patents: Definition - conditions for patentability - test of novelty of patents – composition of a patent - Patenting of Biotechnological discoveries.

Unit 5 **9 Lectures**

Other forms of IPR protection: Copyright - Trademark - Designs - Importance in Indian Scenario & laws in India for IPR protection.

Text Books:

1. Bioethics and Biosafety in Biotechnology by Sree Krishna V., New Age International (P) Ltd., Publ., Mumbai. 2007
2. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, by Deborah E. Bouchoux, CENGAGE Learning Custom Publishing; 4th ed. edition (January 2013).Biodiversity and Conservation by G. Melchias, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2001
3. An Advanced textbook on Biodiversity: Principles and Practice by K.V. Krishnamurthy, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2003.
4. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology by Padma Nambisan, Academic Press, 2017.

Reference Books:

1. The Indian Environmental Protection Act (EPA), 1986.
2. Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989.
3. Food Safety and Standards act (Government of India), 2006. Intellectual Property Rights on Biotechnology by Singh, KC, BCIL, New Delhi, 2004.

COURSE OUTCOME: ***Students will be knowledgeable on national and international regulatory requirement for safe manufacturing, import/export of biological products. Students can understand various types of intellectual properties, international and national laws for protecting them***

BINF 429 – MOLECULAR EVOLUTION

COURSE OBJECTIVES: *The main goal of this course is to help students in learning the basic concepts and computational methods involved in the molecular evolutionary analysis ofgenes and proteins.*

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

Unit 1 9 **Lectures**

Evolution of DNA and proteins, origin of the genetic code. Hardy-Weinberg equilibrium; Evolutionary changes by mutation, gene flow, natural selection and genetic drift.

Unit 2 **9 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 **9 Lectures**

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

Unit 4 **9 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 **9 Lectures**

Evolution of the genome: Human Genome Project, ENCODE, Genome duplication (Ohno's hypothesis), 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. Molecular Evolution and Phylogenetics by Masatoshi Nei and Sudhir Kumar, 2000, Oxford University Press.
2. Neutral Theory of Molecular Evolution by Motoo Kimura, 1985, Cambridge University Press.
3. Bioinformatics and Molecular Evolution by Paul G. Higgs and Teresa K. Attwood, 2013, Willey-Blackwell.

COURSE OUTCOME: *The student will be able to understand the molecular basis of the evolution of the genome. He/she will be able to analyse the genomic data using phylogenetics and infer the evolutionary explanation of a biological phenomenon*

BINF 529 - PYTHON PROGRAMMING FOR BIOLOGISTS

COURSE OBJECTIVES: *To introduce the effectiveness of scripting language concepts with biological applications.*

Total Credits: 3 Total: 45 Hrs*.

UNIT 1 **9 lectures**

Introduction and Overview: A brief history of python – Unique features –Installation of Python and IDE - Lexical structure of python – Introduction of variables and data types with examples. **Statements and control structure**: Introduction to python interpreter and interactive mode –Statement Read and Print commands – Evaluating expressions - Decision, Boolean Logic andRepetition structures syntax with examples in biological application.

Unit 2 **9 lectures**

Functions and Regular expressions: Defining and Calling a function - Fruitful functions (return value, parameters, local and global scope, function composition, recursion) – Examples in sequence analysis using function - Introduction to Modules. **Regular Expression:** Importance of patterns in biology – String manipulation using regular expressions (Extraction, splitting and matching).

UNIT 3 **9 lectures**

Lists, Tuples and Dictionaries: Introduction to Lists – List slicing – Finding items in Lists with operator – Copying and Processing Lists – List built-in methods – Two Dimensional lists. **Tuples:** Basic tuple operations – creation, concatenation, repetition, slicing, immutable and deletion. **Dictionaries**: creation, accessing and processing - Dictionary methods.

UNIT 4 **8 lectures**

Files and Exception Handling: File objects – File built-in methods and attributes - Reading and writing files - command line arguments. **Exception Handling:** Errors and exceptions, Detecting and Handling Exceptions.

UNIT-5 **10 lectures**

Python libraries and Biopython: using standard modules and creating a new module. Introduction to Biopython, installation, important components like seq, seqIO, alignIO, etc. Working with biological data. **RDKit in python**- general molecular functionality- drawing small molecules and other major applications in drug designing.

Text Books:

1. Michael T Goodrich, Micheal S Goldwasser and RoberttoThamassia,. 2016. Data Structures and Algorithms in Python. Wiley Publisher.
2. Martin Jones. 2013. Python for Biologist – A programming course for complete beginners. http://pythonforbiologists.com.
3. Kenneth A. Lambert. 2011. Fundamentals of Python: First Programs. CENGAGE Learning.(ISBN: 978-1111822705).
4. Guido van Rossum and Fred L. Drake Jr. 2011. An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd.

Reference Books:

1. Leonard Eddison. 2018. Python Machine Learning, A Guide for Beginners. 2nd Edition. Kindle Edition.
2. Timothy A. Budd. 2011. Exploring Python. 1st Edition. Mc-Graw Hill Education (India) Private Ltd.
3. Martin C. Brown. 2001. Python The Complete Reference. Osbome/McGraw-Hill

Companies

<u>COURSE OUTCOME</u>: To understand the pros and cons on scripting languages vs. classical programming languages (at a high level) and able to write script in python language for sequence, statistical data manipulation and analysis.

BINF 554 – PROJECT

COURSE OBJECTIVES: *To enable the students to have hands-on research experience and write a comprehensive report and present and defend the same.*

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.

COURSE OUTCOME: *The students will learn to execute a Research Proposal, prepare a Project Report, present and defend the same.*

BINF 523 - BIOPHYSICAL TECHNIQUES

COURSE OBJECTIVES: *To understand the principles of physical sciences that form the basis of the techniques and instrumentation used in research field.*

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

Unit 1 **9 lectures**

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

Unit 2 **9 lectures**

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

Unit 3 **9 lectures**

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

Unit 4 **9 lectures**

Enzyme kinetics: Membrane potential, Active site, Cofactors, apo-enzymes, Enzyme specificity, Factor affecting enzyme activity, Michaelis-Menten, LB Plot, Km/kcat, Types of inhibition, Allosteric enzymes.

Unit 5 **9 lectures**

Macromolecular interactions: Isothermal Titration Calorimetry Optical and magnetic tweezers, Fluorescence Resonance Energy Transfer (FRET) Dual Polarisation Interferometry [DPI] CD/ORD, DLS.

Text Books:

1. Principles and Techniques of Practical Biochemistry (7th Ed) by Keith Wilson and John Walker, Cambridge University Press. 2010.
2. Principles of Biochemistry by Nelson and Cox, Lehninger. W H Freeman & Co. 2009

Reference Books:

1. Physical Biochemistry (2nd Ed) by D. Freifelder., Freeman. 1982
2. Fundamentals of Biochemical calculation (2nd Ed.) by Krish Moorthy CRC Press. 2007
3. Protein Purification - Principles & Practices (3rd Ed.) by R. Scopes., Springer Verlag. 1994
4. Biophysical Chemistry: Techniques for the study of biological structure and functions by Charles C. R. & Paul. S. R., W.H. Freeman & Co. New York. 2004

COURSE OUTCOME: *Students will know the physical basis of appropriate strategies and instrumentation for analysis of different biological sample types.*

BINF 524 - R LANGUAGE AND BIG DATA ANALYTICS

COURSE OBJECTIVE: *The main goal of this course is to introduce the student with the R environment for biological big data analysis using various statistical methods.*

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

Unit 1 **6 lectures**

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

Unit 2 **6 lectures**

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

Unit 3 **6 lectures**

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

Unit 4 **6 lectures**

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

Unit 5 **6 lectures**

Big Data Analytics in Bioinformatics using R: Introduction to Big data: Characteristics, data structures and data repositories; exploratory analysis of big data in R environment, Bioconductor, Microarray and next-generation sequencing (NGS) data analysis in R environment.

Text Books:

1. Paul Gerrard and Radia M. Johnson. Mastering Scientific Computing with R. Packt Publishing, UK, 2015.
2. P.P. Sinha. Bioinformatics with R Cookbook. Packt Publishing, UK, 2014.

Reference Books:

1. Florian Hahne, Wolfgang Huber, Robert Gentleman, Seth Falcon. *Bioconductor case studies.* Springer, 2008.
2. Paul D. Lewis, R for Medicine and Biology, Jones and Bartlett Series, 2010.

COURSE OUTCOME: *The student will have an understanding of various statistical methods employed in biological data analysis. He/she will be able to perform statistical modelling and analysis of microarray and next-generation data in the R environment.*

BINF 525 – MACROMOLECULAR CRYSTALLOGRAPHY

COURSE OBJECTIVES: *The main objective of this course is to make the students to thorough understanding of structural biology of biological macromolecules.*

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

Unit 1 **9 Lectures**

Macromolecules: DNA and RNA- types of base pairing – Watson-Crick and Hoogstein; types of double helices A, B, Z and their geometrical as well as structural features; structural and geometrical parameters of each form and their comparison; various types of interactions of DNA with proteins, small molecules. RNA secondary and tertiary structures, t-RNA tertiary structure. **Proteins**: Principles of protein structure; anatomy of proteins – Hierarchical organization of protein structure – Primary. Secondary, Super secondary, Tertiary and Quaternary structure; Ramachandran Map.

Unit 2 **9 Lectures**

Xray Crystallography: Electromagnetic radiation, origin of X-rays, diffraction basics, Bragg's Law , Miller indices, Scattering from electrons and molecule, Crystal Systems: Seven crystal system, Bravies Lattices, Space groups and Symmetry. Screw axis, glide planes, assignment of space groups, Laue symmetry, crystal twinning, Crystallization Techniques: hanging, sitting drop, seeding, Free=interface diffusion.

Unit 3

Data Collection, Ewald Sphere, reciprocal lattice, Bragg's law in reciprocal space, structure factor, , anomalous diffraction, Friedel pairs, centric and acentric reflections, data processing, indexing, Concept of R factor, symmetry related reflections ,concepts
; multiplicity, completeness,

Unit 4 **9 Lectures**

Phase Problem – What is phase problem, How to solve the phase problem Patterson function, difference Patterson maps Direct methods, Isomorphism replacement method, SIR, SIRAS, SAD, MAD, heavy atom refinement, Figure of Merit, Lack of Closure Error, Phasing Power, solvent flipping, molecular replacement

Unit 5 **9 Lectures**

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

Text Books:

1. Crystals, X-rays and Proteins: Comprehensive Protein Crystallography 1st Edition, Kindle Edition by Dennis Sherwood and Jon Cooper, 2011
2. Fundamentals of Crystallography By Giacovazzo Carmelo, Third Edition 2011.
3. Principles of Protein X-ray Crystallography By Drenth Jan, Third edition, 2007

4. Molecular Modeling Principles and Applications (2nd Ed.) by Andrew R. Leach., Prentice Hall, USA. 2001

5. Principles of Protein Structure by G. E. Schulz., Springer 2009 Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, W. H. Freeman.2005

Reference Books:

2. Introduction to Crystallography By Donald E. Sands, 1st Edition, 1994.
3. Biomolecular Crystallography, Principle, Practice and application to structural biology, Bernhard Rupp
4. Protein Structure and Function By Carl Branden & John Tooze

COURSE OUTCOME: *Students gained the knowledge of structural biology of biological macromolecules.*

BINF 528-COMPUTER-AIDED DRUG DESIGN: FUNDAMENTALS & APPLICATIONS

COURSE OBJECTIVES: Aims to provide Students (non-bioinformatics PG Students) with the knowledge and ability to use computer-assisted methods for the design of new drugs.

Total Credits: 2 Total: 30 Hrs*.

Unit-I **6 lectures**

Introduction to Drugs: How drugs work - Drug targets, drug-target interaction and dose-response relationships; ADME & Bioavailability of drugs – drug-drug interaction & drug toxicity. **New Drug Discovery & Development:** Target & Lead Discovery methods;–Preclinical & Clinical Testing of New Drugs. Regulatory requirement for New Drug approval.

Unit-II **6 lectures**

Medicinal Chemistry: Introduction to the concept of structure-activity relationship (SAR). Effect of functional group modifications, variation of substituents & ring structures on pharmacokinetics & pharmacodynamics properties of drugs. Chirality and drug action. Case studies with kinase inhibitors as anti-cancer therapy.

Unit-III **6 lectures**

Computer-aided drug design (CADD): Introduction to CADD, bioinformatics & chemoinformatics**;** software/tools/webservers used for the design of drugs. **Molecular Mechanics in CADD:** Introduction to molecular mechanics. Force fields and their components - Bonded and non-bonded interactions. Conformational analysis of molecules (comparison between local/global minimum energy conformations and bioactive conformations) and energy minimization.

Unit-IV **6 lectures**

Ligand-based drug design (LBDD): QSAR/ QSPR methodology for drug design - Various Descriptors used in QSAR studies - deriving & validating QSAR equations. 2D vs 3D QSAR. 3D Pharamcophore development - conformation generation, deriving and using 3D Pharmacophores. **Structure-based drug design (SBDD)**: 3D structure of drug targets & homology modeling concepts. Molecular Docking: Docking approaches (Rigid docking vs flexible docking) - Search algorithm & Scoring function. *De novo* ligand design - Linking & growing methods - applications.

Unit-V **6 lectures**

Lead identification & optimization though CADD: Virtual screening for lead identification - drug likeness concept & Lipinski's rule of 5; compound library design (drug-like, fragment-like, natural product, etc), database searching using structure-based and ligand-based methods. Structure-based methods for lead optimization. Case studies with kinase inhibitors as anti-cancer therapy.

Recommended Texts:

1. Molecular Modeling – Principles and Applications by Andrew R. Leach Second Edition, Prentice Hall, USA, 2001.
2. Computational Drug Design: A guide for Computational & Medicinal Chemists by David C Young, John Wiley & Sons, Inc. 2009.
3. The organic chemistry of drug design and drug action by Richard B. Silverman & Mark W. Holladay, Academic Press, 2015.

Reference Books

1. Molecular Modeling: Basic Principles and Applications, by Hans-Dieter Höltje and Gerd Folkers, Wiley-vch Verlag Gmbh, 2008.

2. Burger's Medicinal Chemistry, Drug discovery and Development. Volume 1, Methods in Drug Discovery. 8th Edition. Edited by Donald J. Abraham and Michael Myers, Wiley, 2021.

COURSE OUTCOME: Students will understand how drugs are discovered. Also students will understand the theory behind computer-aided drug design, as well as apply them for drug design.

BINF 527-PYTHON PROGRAMMING LABORATORY

Course Objectives:

- To make students aware of the role of python programing in biology and understand the relevance of multidisciplinary research
- To equip the students with the fundamental concepts of python programing and understand the implementation of Bio-libraries in programming.

Total Credits: 1

1. Installation of Python and IDE
2. Variables and data types
3. Statement read and print commands
4. Boolean logic, statements blocks and conditional statement
5. Conditional loop statement
6. Regular expression
7. List, Tuple, Dictionaries
8. Read a file and write to a File in python
9. Exception handling
10. Bio-python libraries
11. RDKit
12. Python in computer aided drug designing

COURSE OUTCOME:

Students will be able to

Apply their knowledge of computer in life sciences

Create simple python program and implement biopython libraries

Asses various basic programming applications for multidisciplinary research domains