Faculty of Advanced Studies and Research

Syllabus for M.Sc. Medical Biotechnology & Bioinformatics

Academic Year 2020 – 2021

SEMESTER 1

	Course Code	Course*	Credits
Core Courses	PBB1001	Introduction to Bioinformatics	3
	PBB1002	Cell and Molecular Biology	2
	PBB1003	Biochemistry of Macromolecules	2
	PBB1004	Structural Bioinformatics	3
Labs	PBB1101	LAB: Biochemistry and Molecular Biology	3
	PBB1102	LAB: Programming Languages – Python and R	3
CBCS Course	PDS1001	Probability and Statistics	4
		Total	**20**
Sessional	PBB1501	Seminar/Skill-Ex	2

SEMESTER 2

	Course Code	Course*	Credits
Core Courses	PBB2001	Phylogenetics and Evolution of Virulence & Drug Resistance	2
	PBB2002	Medical Microbiology and Immunology	2
	PBB2003	Next-generation Sequencing Data Analysis: Genomics and Transcriptomics	2
	PBB2004	Genetics and Diseases	3
	PBB2005	Proteomics and Metabolomics	2
	PBB2006	Molecular Dynamics Simulation and Docking	3
Lab	PBB2101	LAB: Medical Microbiology and Immunology	2
CBCS Course	PDS2007	Database Design	4
		Total	**20**
Sessional	PBB2501	Seminar/Skill-Ex	2

SEMESTER 3

	Course Code	Course*	Credits
Core Courses	PBB3001	Systems Biology and Biological Networks	2
	PBB3002	Metagenomics and Microbiome	2
	PBB3003	Big Data in Bioinformatics	2
	PBB3004	Medical Genomics and Computer-aided Drug Design	2
	PBB3005	Genetic Engineering and Synthetic Biology	2
	PBB3006	Pharmacoinformatics	3
	PBB3007	Career Development and Entrepreneurship	2
	PBB3008	Intellectual Property Rights	2
	PBB3009	Research Methodology	3
		Total	**20**
Sessional	PBB3501	Seminar/Skill-Ex	2

SEMESTER 4

	Course Code	Course	Credits
Final Project	PBB4001	Thesis with Oral Presentation and Viva Voce	**20**
Sessional	PBB4501	Seminar/Skill-Ex	2

***Any of the theory courses may include practical modules as necessary.**

2 Year M.Sc. in Medical Biotechnology & Bioinformatics

SEMESTER 1

Introduction to Bioinformatics (Credits: 3)

Course Outcomes:

CO1: Students will be able to identify the uses of Bioinformatics

CO2: Understanding the structure of biological data and their acquisition

CO3: Identifying a suitable database, their format and annotations, access

CO4: Understand sequence analysis

1. Bioinformatics-What and why?
2. The structure of biological data and their acquisition, Common sequence file formats, DNA sequence and protein sequence retrieval methods, Protein structure information.
3. Databases – Format and Annotations, Data – Access, Retrieval and Submission, Data retrieval tools.
4. Sequence Similarity Searches: Local versus global. Distance metrics, Similarity and homology. Scoring matrices. Dynamic programming algorithms, Needleman-wunsch and Smith-waterman. Heuristic Methods of sequence alignment, FASTA, BLAST and PSI BLAST.
5. Sequence analysis – Multiple Sequence Alignment and software tools for pairwise and multiple sequence alignment, Whole genome analysis, Genome Annotation and Gene Prediction, Comparative genomics, orthologs, paralogs.

Cell and Molecular Biology (Credits: 2)

Course Outcomes:

CO1: Students will be able to identify Carbohydrate, Lipids and Proteins

CO2: Understanding the general principle of cell signaling

CO3: Identifying biological macromolecules

CO4: Apply tools of molecular biology

1. Cells and its building blocks: Carbohydrate, Lipids and Proteins, Genome Organization: Ultrastructure of prokaryotic and eukaryotic cells and its organelles with their functions, Organization of bacterial genomes.
2. Cell signaling: General principle of cell signaling, basic concept of signaling via G-protein linked cell-surface receptor. Basic aspects in chemical reactions: Significance of Carbon molecule, structure of water, concept of pH/pKa, Buffer, Intra- and inter-molecular interactions (basic concepts), covalent bond, coordinate covalent bond, ionic bond, hydrogen bond, hydrophobic interaction.
3. Biological macromolecules: Nucleic acids, Double helical model of DNA structure Supercoiling of DNA and its importance, Definition of a gene, Nucleosome structure and packaging of DNA into higher order structures, RNA structure and types of RNA, Non-coding RNA, DNA damage, repair and mutation.
4. Tools of molecular biology: Restriction Enzymes, DNA Vectors, Molecular Cloning, High-Throughput Sequencing, Protein-DNA Mapping, Recombinant DNA Technology, Basic concept of plasmid and phage vectors, cosmids, phagemids and other advanced vectors, Gene Cloning Strategies, Mapping and sequencing genomes- Sequencing genes and short stretches of DNA, in situ hybridization.
5. DNA replication and repair, DNA recombination and gene transfer: conjugation, transformation, and transduction, Transcription, Translation, Microbial nutrition and

Bioenergetics.

Biochemistry of Macromolecules (Credits: 2)

Course Outcomes:

CO1: Students will be able to identify Amino Acids
CO2: Understanding Enzymes, Nucleic acids, Vitamins and Coenzymes
CO3: Identifying Bioenergetics and Metabolism
CO4: Apply biochemistry of macromolecules

1. Amino Acids: Structure, nomenclature, classification, acid-base behavior and chemical reactions of amino acids; Stereoisomerism and optical properties of amino acids; Modified amino acids, Protein Structure: Primary structure, Secondary and tertiary structure- Secondary structure of proteins: alpha helix and beta structure; Amino acid sequence and three-dimensional structure; Domains; Forces stabilizing the secondary and

tertiary structure; Protein purification; Criteria of purity, and fold purification, Sequencing, protein folding and denaturation- Protein sequencing, Structure and function of hemoglobin and comparison with myoglobin, Proteins involved in folding, Models of protein folding; Chaperones; Protein conformation and misfold diseases.

2. Enzymes: Enzymes as biological catalysts: characteristics, nomenclature and classification; Enzyme assay and enzyme activity; Enzyme units, Multifunctional enzymes, Isoenzymes and their analysis; Ribozyme, Enzyme mechanisms: Enzyme kinetics and enzyme inhibition, Steady-state hypothesis and derivation of Michaelis-Menten equation; Significance of Km and Vmax and their determination using different plots; Double reciprocal plot; Enzyme inhibition: competitive, noncompetitive, and uncompetitive inhibition; Excess substrate inhibition; Enzyme kinetics in the presence of inhibitors, Enzyme catalyzed reactions involving two substrates, Catalytic mechanisms-Catalytic efficiency and factors associated with catalytic efficiency, Catalytic mechanisms: acid-base, covalent, metal ion and electrostatic catalysis, Mechanism of action of lysozyme and serine proteases, Regulation of enzyme activity and immobilized enzymes, Allosteric enzymes and their kinetics, Enzyme immobilization: methods, kinetics and applications, Non-enzymatic biochemical reactions.
3. Nucleic acids: Nucleic acids- types and structural organization, triple helix of DNA-DNA denaturation and renaturation- hypochromicity- Tm; RNA: Structure function and types of RNAs; unusual bases in RNA; Replication and Transcription; Translation and post-translational modifications, Lipids and Membranes: Classification and types of lipids; Structure, nomenclature and properties of fatty acids; Composition and biological role of lipoproteins; Structure and functions of steroids and prostaglandins; Eicosanoids.
4. Vitamins and Coenzymes: Vitamins: structure and function in detail, Carbohydrates: Occurrence, classification, characteristics, structure and functions of mono-saccharides, disaccharides, trisaccharides and polysaccharides; Structure and conformation of sugars; Stereoisomerism and optical isomerism; Selected chemical reactions of the functional groups; Sugar derivatives; Mucopolysaccharides; Glycosaminoglycans; Proteoglycans; Glycoproteins.
5. Bioenergetics: Laws of thermodynamics; Concept of free energy, and standard free energy change; Determination of free energy change for a reaction; Equilibrium constant and standard free energy change; Biological oxidation-reduction reactions; Standard reduction potential and its relationship with free energy change.
6. Metabolism: Metabolic pathways: Characteristics of metabolic pathways; Strategies used to study metabolic pathways, High energy compounds: ATP as universal energy currency in biological systems; Carbohydrate Metabolism: Digestion and absorption of carbohydrates; Glycolysis, Gluconeogenesis; Citric acid cycle; Pentose phosphate pathway; Glucuronate pathway, Glycogen metabolism and its regulation; Glycogen storage diseases and other genetic defects in carbohydrate metabolism; Regulation of carbohydrate metabolism; Metabolic adaptation in starvation and diabetes mellitus.

Structural Bioinformatics (Credits: 3)

Course Outcomes:

CO1: Students will be able to identify the fundamental concepts of structural biology
CO2: Understanding structural basis for the dynamics, binding specificity
CO3: Identifying automated domain
CO4: Apply sequence analysis for prediction of secondary and tertiary structures

1. Fundamental concepts of structural biology – chemical building blocks, structures, superstructures, folding, relation between sequence, structure and function, Basic macromolecular structure: three-dimensional structure, PDB coordinates, classification of proteins in structure families, programs comparison of structures, function of macromolecules.
2. Structural basis for the dynamics, binding specificity, catalysis and cooperativity of macromolecules.
3. Automated domain identification- classification and comparison of sequences and

extraction of common distinctive features, Protein functional site prediction, Structural superposition and structure alignment.

4. Sequence analysis for prediction of secondary and tertiary structures, Secondary structure assignment and prediction. Tertiary structure prediction, Analysis of protein structures and quality assurance, Structure visualization, Overview of protein structural databases software tools.

LAB: Biochemistry and Molecular Biology (Credits: 3)

Course Outcomes:
CO1: Students will be able to measure pH and pH titration
CO2: Understanding protein purification by ammonium sulfate precipitation
CO3: Identifying amino acids, carbohydrates, nucleic acid
CO4: Apply tools of Biochemistry and Molecular Biology

Biochemistry Lab:

1. Laboratory safety
2. Buffer preparation, pH measurement and pH titration
3. Measurement of UV-Visible absorption spectra and verification of Beer-Lambert's Law
4. Protein purification by ammonium sulfate precipitation
5. Estimation of protein by Biuret method
6. Purification & Estimation of Casein in milk
7. Paper Chromatography of amino acids, carbohydrates, nucleic acid
8. Estimation of Enzyme activity
9. Estimation of cholesterol

Molecular Biology Lab:

1. DNA gel electrophoresis
2. Plasmid isolation
3. Restriction digest of DNA and analysis
4. Introduction to Cloning- bacterial transformation

LAB: Programming Languages – Python & R (Credits: 3)

Course Outcomes:
CO1: Students will be able to measure basic data structure in python and its applications
CO2: Understanding design and implementation of customize generator using python
CO3: Identifying .csv,.txt,.html,.xml using Pandas
CO4: Apply implementation of Multithreading application using Python

1. Basic Data Structure in Python and its applications using sequential conditional and iterative flow of control (String, List, Dictionaries, Tuples, Set)
2. Indexing & Slicing with shorthand's notation.
3. Formatted and f'-string formatting in console output
4. Design and implementation of function in Python that takes variable arguments
5. Design and implementation of method overloading using weakly typed (implicit) design.
6. Implementation of Iterator in Python
7. Design and Implementation of customize Generator using Python
8. Implementation of Map Filter with console input.
9. Creation of Packages and Sub Packages using Python
10. Implementation of Lambda expression using Python
11. Lambda expression and its association with Map, Filter
12. Regular Expression in Python
13. IO and Exception Handling using Python
14. Design and implementation of Multithreading application using Python
15. Implementation of Numpy arrays and its functionalities.
16. Read write update .csv,.txt,.html,.xml using Pandas
17. Implementation of Pandas –Series, DataFrame and uses of their inbuilt methods

18. Data visualization using matplot libraries
19. Basic design and architecture of OOP in Python
20. Design and implementation of Decorator Pattern using Python
21. Introduction and basic building block of R
22. Sequential conditional and iterative flow of control using R
23. Design and implementation Bayesian algorithm.
24. Design and Implementation of PDF PMF Estimator in R

Probability and Statistics (Credits: 4)

Course Outcomes:

CO1: Students will be able to understand descriptive statistics
CO2: Understand Probability
CO3: Identifying analytical models
CO4: Apply and implementation of these in R using appropriate packages

1. Descriptive Statistics: Frequency Distributions, Graphical Representations of Data, Measures of Central Tendency, Skewness and Kurtosis, Scatter Plots for Bivariate Data, Pearsonian Correlation, Spearman's Rank Correlation
2. Probability: Random Variables, Probability Mass Functions, Continuous and Absolutely Continuous Probability Distribution Functions, Conditional Probability, Bayes Theorem
3. Analytical Models: Simple Linear Regression, Multiple Linear Regression, Partial Linear Regression, Logistic Regression, ANOVA, Hypothesis Testing including the z-test,paired and unpaired t-test, F-test, chi-square test, etc., Goodness of Fit
4. Implementation of these in R using appropriate packages.

SEMESTER 2

Phylogenetics and Evolution of Virulence & Drug Resistance (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand phylogenetics
CO2: Understand Impact of homoplasy and recombination in phylogeny
CO3: Identifying Ecological roles of antibiotics and antibiotic resistance
CO4: Identification of virulence factors

1. Introduction to phylogenetics
2. Types of phylogenetic trees
3. Methods of phylogenetic reconstruction
4. Impact of homoplasy and recombination in phylogeny
5. Two complementary approaches addressing bacterial virulence
6. The starting point of virulence evolution
7. Identification of virulence factors
8. Evolution toward virulence
9. Loss of virulence
10. Virulence – a rare exception or the rule?
11. History of antibiotics
12. Superbugs and super resistance
13. Mechanisms and origins of antibiotic resistance
14. Genetics of resistance
15. Ecological roles of antibiotics and antibiotic resistance
16. Ways to combat development of antibiotic resistance

Medical Microbiology and Immunology (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand structural classification of microbiology
CO2: Understand methods in microbiology
CO3: Identifying microbial growth
CO4: Apply regulation of immune response and Immunological techniques

Microbiology

1. Structure, classification and general characteristics of bacteria, mycoplasma, protozoa, archaea, viruses and fungi
2. Methods in microbiology
3. Sterilization- Microbial contamination control; Various sterilization methods and their application in biotechnology
4. Microbial growth and its mathematical expression.
5. Life cycle and replication of different anima viruses and bacteriophage
6. Host virus interactions and antiviral therapy.

Immunology

1. Fundamentals and anatomy of immune system
2. Regulation of immune response
3. Vaccines – Active and passive immunization

4. Hypersensitivity and Autoimmunity
5. Transplantation and tumor immunology
6. Immunodeficiency diseases
7. Immunological techniques

Next-generation Sequencing Data Analysis: Genomics and Transcriptomics (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand Next-Generation sequencing

CO2: Understand NGS data analysis

CO3: Identifying genome analysis

CO4: Apply and implementation of methods for RNA-seq analysis

1. Introduction to Next-Generation sequencing (NGS): Overview, history and development of sequencing techniques; Basic terms and principles; NGS applications and workflow; NGS technologies and platforms; Library preparation; Standard applications and techniques.

2. NGS data analysis: Overview, data analysis environments and bioinformatic workflows; NGS data files and formats; Quality assessment and data pre-processing; Software overview; Controlling for errors; Data analysis issues and pitfalls; Perspectives from the NGS industry/data analysts; Data visualization with Genome browsers (UCSC, IGV).

3. Methods for genome analysis: Quality control of datasets, mapping, assembly and annotation; Comparative genomics and Pan-genomics; Functional genomics.

4. Methods for RNA-seq analysis: Quality control of datasets, Filtering, adapter removal, Spliced alignment to transcriptome, Post alignment QC, Transcript quantification, Differential gene expression analysis, pathway analysis; Overview of ChIP-seq , ATAC-seq, Bisulfite sequencing and single cell sequencing.

Genetics and Diseases (Credits: 3)

Course Outcomes:

CO1: Students will be able to understand Genetics

CO2: Understand Mendelism

CO3: Identify significance of epigenetics

CO4: Apply transcriptomics in pharmaceutical research

1. Introduction to Genetics: Concept of gene, Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes, Hereditary traits, Genetic Disease, Mutations and polymorphisms, Genome mapping, Chromosomal basis of Heredity: Histones, nucleosome morphology and higher level organization, Human Chromosomes – types, Giant chromosomes (Polytene and lampbrush chromosomes), Chromosomal anomalies (Numerical and structural alterations, induced chromosomal aberrations in somatic cells), Cytogenetics: Chromosome labeling and cell cycle analysis, Overview of mitosis and meiosis
2. Mendelism: Mendel and his experiments, Law of Mendel, Multiple allelism, Complementation test, Intragenic complementation, Visible, sterile and lethal mutations, effect of the environment on phenotype development- penetrance and expressivity, Gene interactions and modifying genes, Pleiotropy, Inheritence, Linkage and Crossing over: Sex-linked inheritance, Genetic recombination, Intragenic recombination, Continuous and discontinuous variation, Polygenic inheritance, Cytoplasmic inheritance, maternal effects, Mitochondrial inheritance.

3. Somatic Cell Genetics and stem cell research: Somatic cell hybridization, significance of stem cells in gene therapy, Epigenetics: What is Epigenetics, significance of epigenetics with regard to DNA and histone modifications.
4. Genome Wide Gene Expression Analysis: Technique of Microarray, Analysis of Microarray data (K-Means Clustering, Hierarchical Clustering, Self Organizing Maps (SOM), Principal Component Analysis), Transcriptomics in human cancer hazard assessment, Transcriptomics in Phylogenetics applications, Transcriptomics in Pharmaceutical Research, Microarray databases, Tools for Transcriptome Analysis.

Proteomics and Metabolomics (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand Proteomics

CO2: Understand techniques in Proteomics

CO3: Identifying applications of protein engineering in chemical and medical Industries

CO4: Apply Data processing in Metabolomics

1. Introduction to Proteomics: Proteomes: an overview and importance, Significance of proteome analysis: Basic principles of protein purification, separation and characterization; Gel-based proteomics-two-dimensional gel electrophoresis (2-DGE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Staining methods, PF-2D, Tandem FPLC, Protein- protein interactions, techniques for enrichment of modified proteins.
2. Techniques in Proteomics: Gel based proteomics, LC-based proteomics, Protein Identification and data evaluation, Identification of post-translational modifications: Phosphorylation, Glycosylation, Acetylation, Importance of Protein modifications in cell functions, Mass Spectrometry, ionization sources, Mass analyzers, Tandem mass spectrometry, Nuclear magnetic resonance spectroscopy (NMR), X-ray Crystallography: Principle of X-ray diffraction, Circular Dichroism, Miller indices, crystal lattice, Bragg's Law, special properties of protein crystals, model building, refinement and R-factor.
3. Protein Engineering: Industrial and medical application of proteins, different expression of proteins for large scale purifications, protein engineering strategy, rational and random mutagenesis. Applications of protein engineering in chemical and medical Industries, Generation of heat stable, pH stable enzymes, application in vaccine development, drug development, sensor development.
4. Concepts in structural proteomics: Protein sequence, fold and function, Relationship between protein function and structure, Databases and handling of sequence data, protein structure alignment, predictions of protein patterns, motifs and profiles, Different methods for computer-based modelling of protein structures.
5. Introduction to metabolomics: Main concepts, Analytical process in metabolomics, Design of a metabolomics experiment, Quality Control and Quality Assurance Procedure in Metabolomics, Targeted metabolomics, Untargeted metabolomics, Quantitative metabolomics, Data processing in Metabolomics: Pre-processing of analytical data, alignment, normalization, scaling, filtering, Statistical analysis of the data, Metabolite databases, Identification of metabolites, From data identification to pathways, Clinical and biochemical applications.

Molecular Dynamics Simulation and Docking (Credits: 3)

Course Outcomes:

CO1: Students will be able to understand molecular mechanics

CO2: Understand Molecular Dynamics Simulation

CO3: Identifying free energy calculations

CO4: Apply and implementation of applications of 3D database searching and docking

1. Molecular Mechanics: Introduction, The Morse Potential, The Harmonic Oscillator Model for Molecules, Comparison of Morse and Harmonic Potential, Two atoms connected by a bond, Polyatomic Molecules, Energy due to Stretch, Bend, Stretch-Bend, Torsional strain, van der Waals and Dipole-Dipole interactions. Concept of force field, Energy optimization: potential energy functions, Energy minimizations: non-derivative, first order and second order methods.

2. Molecular Dynamics Simulation: Introduction, Integrators- Leapfrog and Verlet algorithm, Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations, Setting and running simulation script, Constraint dynamics, Time dependent properties.
3. Free energy calculations: thermodynamic integration, free-energy perturbation.
4. Docking: Introduction of molecular docking, scoring functions, applications of 3D database searching and docking.

LAB: Medical Microbiology and Immunology (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand Safety and Aseptic Technique

CO2: Understand Cellular Characteristics

CO3: Identifying antibiotic testing and antibiotic resistance

CO4: Apply and implement MIC Determination and Protein purification

1. Introduction to Safety and Aseptic Technique
2. Cultural and Growth Characteristics
3. Cellular Characteristics
4. Metabolic/Enzymatic Testing/Analysis
5. Dilutions
6. Applied Medical Microbiology lab
7. Antibiotic Testing and Antibiotic Resistance
8. MIC Determination
9. Protein purification
10. Western Blotting

LAB: Database Design (Credits: 4)

Course Outcomes:

CO1: Students will be able to understand concept & overview of database design

CO2: Understand database design

CO3: Identify database connection through java/python/php

CO4: Apply and implementation database connection

1. Introduction: Concept & Overview of DataBase Design (DBD), Purpose of DBD, View of Data, Database Languages, Database Users and Administrators.
2. Relational Databases: Database Schema, Keys, Schema Diagram, Relational Query Languages, SQL, SQL Data Definition, SQL Queries, Set Operations, Null Values, Aggregate Functions, Nested Subqueries, Modification of the Database, Join Expressions, Views, Transactions, Integrity Constraints, Triggers, Relational Algebra, Relational Calculus.
3. Database Design: Entity-Relationship Model, Constraints, E-R Diagram, Reduction to Relational Schemas, E-R Design Issues, Extended E-R Features, Functional Dependency, Normalization using functional dependencies, Decomposition, 1NF, 2NF, Boyce-Codd Normal Form, 3NF, Normalization using Multivalued Dependencies, 4NF, 5NF.
4. DataBase Connection through Java/Python/PHP.

SEMESTER 3

Systems Biology and Biological Networks (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand the concepts and working principles of System Biology

CO2: Understand fundamentals of networks

CO3: Identifying Microarray analysis platforms

CO4: Apply Global protein function prediction from protein-protein interaction networks

1. Introduction to Systems Biology: Concepts and working principles of System Biology - Practical applications of System Biology in Life Sciences. Introduction to System Biology platforms Proprietary system Biology platform. Different Markup languages used in systems biology, Modeling protein-protein interactions with ODEs, Modeling bio-chemistry with Petri Nets, Modeling molecular biology using Kappa.
2. Microarray data analysis - Microarray analysis platforms - Introduction to Concepts and principles of Microarray technology - Application of Microarrays in Life Sciences.
3. Fundamentals of networks, Network representations and statistics, Random graph models, Predicting missing links and attributes, Network measures and random network models, Protein-protein interaction networks, Global and local network alignment, Network modules, Modeling of Protein Interaction Networks, Specificity and Stability in Topology of Protein Networks, Functional and topological characterization of protein interaction networks, Lethality and centrality in protein networks.
4. Exploring Complex Networks, Complex networks: Structure and dynamics.
5. Global protein function prediction from protein-protein interaction networks, Networks in

disease and drug development, Network integration, Functional subnetwork inference.

Metagenomics and Microbiome (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand Metagenomics

CO2: Understand the Techniques in Metagenomics

CO3: Identifying Industrial applications

CO4: Apply potential of the microbiome to diagnose, prevent & treat disease.

1. Introduction to Metagenomics: About metagenomics; Different types of metagenomes (Amplicon, Shotgun, Functional) and their history & approach; Application of metagenomics in Biotechnology and Healthcare.
2. Techniques in Metagenomics: Sequencing technologies available; Sequencing platform specific issues; Construction of metagenomic library; Quality Controls; Mapping sequence reads & taxonomic annotation; Metagenome assembly; Diversity analysis; Functional annotation & determination; Gene prediction; Comparative metagenomics; Different tools & algorithms in metagenomics.
3. Metagenomics and Microbiome: Metagenomics and its application in soil microbiome; Metagenomic analysis of Bacteriophage; Archaeal metagenomics; Ocean microbiome; Earth Microbiome Project; Industrial applications.
4. Human Microbiome: About Human Microbiome; Human Microbiome Project; Hologenome Theory; Techniques used to study human microbiome data; Functional studies of microbiome; Role of microbiome in human diseases; Potential of the microbiome to diagnose, prevent & treat disease.

Big Data in Bioinformatics (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand big data and Hadoop

CO2: Understand basics of apache spark

CO3: Identifying distributed key-value pairs

CO4: Apply and implementation of structured data and Hadoop Ecosystem

1. Introduction to big data and Hadoop: Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Ecosystem.
2. Apache spark basics: Gate up and running with Scala. Scala crash course. Data Parallel to Distributed Data Parallel, Latency RDDs, Spark's Distributed Collection, RDDs: Transformation and Actions Evaluation in Spark: Unlike Scala Collections! Cluster Topology
3. Reduction operations & distributed key-value pairs: Reduction Operations, Pair RDDs, Transformations and Actions on Pair RDDs, Joins
4. Partitioning and Shuffling: Shuffling: What it is and why it's important, Partitioning, Optimizing with Partitioners, Wide vs. Narrow Dependencies.
5. Structured data: SQL, Dataframes and Datasets: Structured vs Unstructured Data, Spark SQL, DataFrames, Datasets, SPARK Streaming.
6. HDFS (Hadoop Distributed File System): The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume

and Sqoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.

7. Hadoop Ecosystem PIG: Introduction to PIG, Execution Modes of PIG, Comparison of PIG with Databases, Grunt, PIG Latin, User Defined Functions, Data Processing operators. Hive: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS, Big SQL : Introduction
8. Capstone project.

Medical Genomics and Computer-aided Drug Design (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand medical genomics
CO2: Understand Computer-aided Drug Design
CO3: Identifying process of Drug Discovery
CO4: Apply key bioinformatics tools and concepts used for data analysis and interpretation

1. Introduction: What is medical genomics? What makes one more or less susceptible to a disease: genomic and other determinants, Different types of genomic data: genomes, exomes, transcriptomes, immune repertoires, pathogen-genomes, etc, Modern sequencing technologies used in medical genomics.
2. Key bioinformatics tools and concepts used for data analysis and interpretation: mapping, variant calling, haplotype assembly, structural variation, Single nucleotide polymorphisms, Copy number variation, Sequence-based diagnostics: prenatal and rare disease, Pharmacogenomics and personalized treatment.
3. Tracing human populations, Genome wide association studies, Genomic analysis and targeted therapies, from rare mutation to mainstream drug target, Mosaics and chimeras, Understanding the causes of rare diseases.
4. The human microbiome, Immunity and auto-immune diseases: a genomic perspective, Pathogen genomics: diagnostics, drug resistance, and vaccine design, Clinical trials and efficacy evaluation in the age of medical genomics, Ethical considerations and complications of medical genomics.
5. Computer-aided Drug Design: Concepts and Principles, 2D and 3D QSAR, Docking and protein-ligand structural recognition techniques, Pharmacophore generation, Advanced concepts in Structural Bioinformatics.
6. The process of Drug Discovery: Identification of therapeutic target molecules, Chemical similarity search methods, Molecular docking, and virtual high-throughput screening, Search algorithms, Scoring methods, Challenges in Molecular docking, Structure based De Novo Ligand Design, Drug Receptor Interaction, Computational assessment of activity and toxicity and drugability.

Genetic Engineering and Synthetic Biology (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand Genetic Engineering
CO2: Understand cloning vectors and plasmid vectors
CO3: Identifying Recent trends in genetic engineering
CO4: Apply structural and functional properties of biomolecules

1. Introduction to Genetic Engineering, Molecular tools for gene cloning: Nucleases, Restriction Enzymes, RNases, Methylases, Polymerases, Klenow Fragments, Reverse Transcriptase, Ligases, Topoisomerases etc., Principles of Electrophoresis, AGE & PAGE, Principles of Blotting: Southern, Western & Northern, Polymerase Chain Reaction (PCR), RT-PCR, Real Time PCR, Gene Tagging, Gene mapping & Gene Knockout.
2. Introduction to cloning vectors, Desirable properties of vectors, Plasmid Vectors , Phage

Vectors, Cosmids, Phasmids, Artificial chromosomes BACs, YACs, PACs, Expression Vectors, Cloning strategies and DNA libraries, cDNA cloning & cDNA libraries, Genomic libraries & Screening of libraries and recombinant clone selection, Site Directed Mutagenesis, DNA Protein Interactions: DNA Footprinting, Protein Protein Interactions.

3. Recent trends in genetic engineering: Targeted Genome Editing, Gene Targeting: Knock-ins & Knock-outs, DNA Fingerprinting.
4. Overview of synthetic biology: history, current, and future, Biological background of gene regulation2. Experimental foundation for gene circuit construction, applications of synthetic biology, CRISPR-Cas system, directed evolution, Experimental characterization of structural and functional properties of biomolecules.

Pharmacoinformatics (Credits: 3)

Course Outcomes:

CO1: Students will be able to understand Pharmacoinformatics

CO2: Understand Chemoinformatics

CO3: Identifying Compartment Models of Pharmacokinetics

CO4: Apply Gene silencing techniques

1. Introduction to Pharmacoinformatics: Classification of drugs, Major sources of drugs, Common filters for drugs design, Molecular descriptors, Structure activity relationship, Pharmacophore and pharmacophoric graph, Physicochemical parameters in Drug design, Basics of Drug Action, Pharmacological Screening and Assays.
2. Chemoinformatics: In-silico representation of chemical information, Crystallographic Information Framework, CML Chemical Markup Language, SMILES -- Simplified Molecular Input Line Entry Specification, Chemical Databases and Data Mining, Molecular Drawing and Interactive Visualization (ChemDraw, MarvinSketch, Chimera, RasMol, PyMol).
3. Pharmacokinetics: Compartment Models, Pharmacokinetic parameters, Absorption, Distribution, Metabolism, Excretion, Multiple doses, Salt factor, Bioavailability, Clinical case studies.
4. Pharmacodynamics: Drug receptor action, Direct physiological action, Drug-drug interaction, Polymorphism and drug metabolism, Drug potency and efficacy, Agonists and antagonists, Receptor-effector coupling, Spare receptors, Therapeutic index.
5. Pharmacogenomics: SNPs analysis, Statistical methods, Gene-gene interaction, Gene–environment interaction, Gene silencing techniques, Tools used in pharmacoinformatics, Case studies and applied pharmacoinformatics.

Career Development and Entrepreneurship (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand the concept of Entrepreneurship

CO2: Understand Motivation and Approaches in Entrepreneurship

CO3: Identifying Business Opportunity

CO4: Apply institutional support system

1. Introduction to Entrepreneurship, Motivation and Approaches in Entrepreneurship.
2. Management Concepts and Organizational behavior.
3. Development of Entrepreneurial skills.
4. Business Opportunity Identification, Market Research, Financial Information & Operations, Marketing & Sales.
5. Small Business Management.
6. Institutional Support System.

Intellectual Property Rights (Credits: 2)

Course Outcomes:

CO1: Students will be able to understand biosafety

CO2: Understand bioethics

CO3: Identifying intellectual property rights

CO4: Generate patentable ideas

1. Biosafety: Definition of bio-safety, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns. Biosafety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety. Biosafety regulation: handling of recombinant DNA products and processes in industry and in institutions.
2. Bioethics: The legal and socioeconomic impact of biotechnology, biotechnology in international relations, globalization and development, Social and ethical issues in biotechnology, Principles of bioethics, Ethical conflicts in biotechnology-interference with nature, unequal distribution of risk and benefits of biotechnology.
3. Intellectual Property Rights: Intellectual property rights, International conventions patents and methods of application of patents, forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property. WTO: agency controlling trade among nations, WTO with reference to biotechnological

affairs, Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents, Indian patent act and foreign patents, Patentability, Patent application, Revocation of patent, Commercialization and Licensing.

Research Methodology (Credits: 3)

Course Outcomes:

CO1: Students will be able to understand Foundation of Research

CO2: Understand review of literature

CO3: Identifying research problem

CO4: Formulate research design

1. Foundation of Research: What is Research, Objectives of Research, Scientific Research, Research and Theory Conceptual and Theoretical Models, Research Process, Problem definition, Research Questions, Research design, Approaches to Research, Importance of reasoning in research.
2. Review of Literature: Significance for Reviewing Literature, What to Review and its Purpose, Literature Search Procedure, Sources of Literature, Tools for identifying literatures, Note Taking, Role of libraries in Information Retrieval, Referencing, Indexing and abstracting services, Citation indexes.
3. Research formulation and design: Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis Formation, Measurement, Research Design/Plan.
4. Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments.
5. Methods of data collection: Meaning and Importance of Data, Sources of Data, Use of Secondary Data, Methods of Collecting Primary Data, Observation Method, Simulation.
6. Processing of Data: Editing, Classification and Coding, Transcription, Tabulation, Numerical and Graphical Data Analysis: Sampling: Sampling Techniques or Methods, Choice of Sampling Techniques, Sample Size, Sampling and Non-Sampling Errors, Observation, Surveys, Inferential Statistics, Statistical Analysis of Data, and Interpretation of Results.
7. Preparation of Dissertation and Research Papers: Types of Research Papers, Planning of Writing, Research Report Format, Principles of Writing, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents.