Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 8 Biotechnology & Bioinformatics

- Bioinformatics
- Molecular Biology and Biotechnology

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Compiled By

Dean & Director of Instruction Co-Ordination Committee of SAU's 2022-23

Restructured and Revised Syllabi of Post Graduate Programmes

M. Sc. and Ph. D. (Agriculture) in Bioinformatics

Compiled by

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Preamble

Driven by the recent developments in high throughput Genomics, Bioinformatics is taking an ever-increasing role in Agri-genomics. In a similar way, advances in information technology and computational methods are driving the mathematical sciences forward. Artificial Intelligence and Big Dataanalytics have revolutionized the bioinformatics-based genome data analysis. Now with the availability of next generation sequencing technologies, a high volume of both structured and unstructured data is available. Further, data is also available from many genome data repositories like Gen Bank at National Centre for Biotechnology Information in the public domain. All these have led to the availability of the huge amount of data from different agricultural organisms that need to be analyzed and elicit the hidden information for knowledge discovery to unravel the underlying complex biological phenomena.

In order to achieve the goals of bioinformatics: (i) designing of algorithms for handling and analysis of genomic bigdata (ii) development of statistical-computational methods and techniques, automated pipelines, tools for high dimensional genome data analysis (iii) accessing the existing databases and sharing the developed tools and databases in public domain; planning strategies and human resources are to be developed in genomics research to solve the national level problems and issues. To mention a few, the priority areas are: (i) plant and animal improvement through genomics-assisted breeding and genomic selection (ii) climate smart crop production for food security (iii) metagenome wide association study of soil microbiome with crop productivity by machine learning (iv) GWAS, PheWAS and phenomics aided improvement programmes (v) artificial intelligence (AI); machine learning – an approach to achieve AI; and deep learning– a technique for implementing machine learning; for knowledge discovery through agri-genomics (vi) block chain technology and data science for agricultural value chain (vii) role of microbiota in plant and animal health care and expression of economically important traits (viii) designing and development of Agri-Encyclopedia of DNA Elements (A-ENCODE) (ix) identification of bioremediation bacteria and probiotics from Indian river system for pollution remediation (x) improved and efficient algorithms for robust genome assembly from data generated under different Next Generation Sequencing platforms. Possessing expertise and skills in computer programming languages like R and pythonis essential for bioinformaticians,

who are developers of bioinformatics tools and pipelines in the system. Above all, there exists always a rapidly increasing demand for individuals to be trained in bioinformatics with special skills and knowledge to handle high dimensional genomic data. The emerging trends in genomic research, need for human resources for teaching and application of bioinformatics in genomic research for crop improvement, shrinking job opportunities in the public sector etc would warrant students to possess the technical knowledge and skills in bioinformatics coupled with good practical and management skills, to be competitive for both public and private sectors. Hence a thorough restructuring of course curriculum and delivery system is needed.

In this revised course curriculum of Bioinformatics, the BSMA sub-group constituted at SAU level , organized a series of meetings to develop the courses for M.Sc. and Ph.D. programs for the SAUs of Maharashtra State..The meetings were focused on keeping different courses on AI/ML/DL, programming languages, big data analytics in the curriculum without compromising on the quality and the content in terms of imparting the requisite upto date knowledge to the students. Thus, the basic platform courses are kept as core courses that need to be taken by all the students irrespective of the subject specialization from which they entered the PG education. The course curriculum also targets the M.Sc. and Ph.D. students separately by providing two sets of courses and advanced courses to the Ph.D. students only. Also, substantial inputs were provided by the experts to introduce recent developments in the advanced courses so that the concepts are ingrained when the M.Sc. graduates enter to the Ph.D. system. An additional input received during discussion was on enabling the SAUs and Deemed-to-be Universities to have reasonably good infrastructure that helps students to have comprehensive knowledge with hands on training. This will help the students build confidence in becoming entrepreneurs in bioinformatics, get employment in R & D companies so that the gains in education gets translated to the end user, the producers, processors and the consumers.

The new look and restructured PG programme in bioinformatics has been designed by considering the needs of private sector, modern statistical and computational methods, algorithms, artificial intelligence and machine learning, and big data science to enhance the global competitiveness and employability of the students. Thus, considerable and markable efforts have gone into the preparation of the present revised course curriculum of Bioinformatics.

Committee on Bioinformatics

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes	Broad Subject Coordinator (Chairman of all Disciplines' Sub Committees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Basic Sciences	Bioinformatics	M.Sc. (Agri.) Bioinformatics & Ph.D. (Agri.) Bioinformatics	Prof. H.B. Patil, Associate Dean and Principal, VDCoAB, Latur (VNMKV, Parbhani) E-mail: hbpatil2003@yahoo.com Mobile:9422176266	Dr. R.L. Chavhan Asstt. Professor, Plant Biotechnology, VDCoAB, Latur (VNMKV, Parbhani) E-mail: rlchavhan@gmail.com Mobile:7588611027

Organization of Course contents & Credit Requirements

Minimum Residential Requirement:
M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Nomenclature of Degree Programme

- M.Sc. (Agri.) in Bioinformatics
- Ph.D.(Agri.) in Bioinformatics

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.

Eligibility for Admission

M.Sc (Agri.) in Bioinformatics:
B.Tech (Biotechnology)/B.Sc.(Agril. Biotechnology)/B.Sc.(Agri.)/ B. Sc. (Hons.) Agriculture/ B. Sc. (Hort.)/ B.Sc. (Hons.) Horticulture/ B. Sc. (Forestry)/ B.Sc. (Hons.) Forestry or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Bioinformatics conducted by competent authority.

PhD.(Agri.) in Bioinformatics:
Master Degree in the discipline of Bioinformatics and Molecular Biology and Biotechnology having appearing the Common Entrance Test of Bioinformatics subject conducted by competent authority.

Course and Credit Requirements:

Course Details	Masters Degree	Doctoral Degree
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common PGS courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

M.Sc.(Agri.) in Bioinformatics
Course Structure

LIST OF CORE COURSES/ COMPULSORY/SUPPORTING COURSES

Major courses (12+8 credits):

Course Code	Semester	Course Title	Credit Hrs.
BI 501*	I	Introduction to Bioinformatics & Computational Biology*	2+1
BI 502*	II	Statistical Genomics*	2+1
BI 503	I	Genome Assembly and Annotation	1+1
BI 504*	II	Biomolecular Modelling and Simulation*	2+1
BI 505	I	Transcriptomics and Metagenomics	2+1
BI 506*	II	Biological Data Management*	2+1
BI 507	I	Biological network modelling and analysis	2+1
BI 508	II	Computer programming in bioinformatics	2+1
BI 509	I	Machine Learning Techniques in bioinformatics	2+1
BI 591*	III	Master's Seminar	0+1
Total			**17+10=27**
BI 599	III & IV	Master's Research	0+30

*Core courses & compulsory courses

Minor and Supporting Courses for Masters degree:

Minor Disciplines (8 credits):

1. Molecular Biology and Biotechnology
2. Biochemistry
3. Genetics and Plant Breeding
4. Microbiology
5. Seed Science and Technology
6. Plant Physiology
7. Organic Farming
8. Computer Science and Information Technology

Suggestive minor courses:

Followings are the list of suggestive minor courses.Students will be required to complete minor courses (8 credits) from the below courses from minor disciplines related to the major discipline in which student admitted and as decided by the Student Advisory Committee.

Course Code	Semester	Course Title	Credit Hrs.
MBB 501	I	Principles of Biotechnology	3+0
MBB 502	I	Fundamentals of Molecular Biology	3+0
MBB 517	II	Stress Biology and Genomics	2+0
BIOCHEM 501	I	Basic Biochemistry	3+1
GPB 506	I	Molecular breeding and bioinformatics	2+1
MICRO 502	I	Principles of Microbiology	3+1
PP 503	I	Plant Developmental Biology: Physiological and Molecular Basis	2+1
SST 501	II	Seed Development Biology	1+1

Supporting Courses Disciplines (6 credits):

1. Statistics
2. Mathematics
3. Computer Science and Information Technology
4. Molecular Biology and Biotechnology
5. Biochemistry
6. Genetics and Plant Breeding
7. Microbiology
8. Plant Physiology

Suggestive supporting courses:

Followings are the list of suggestive supporting courses.Students will be required to complete supporting courses (6 credits) from the below courses and may be taken other courses from above disciplines related to the major discipline in which student admitted and as decided by the Student Advisory Committee.

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Compulsory Common PGS Courses (5 credits Non Credit):

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1
PGS 502	I	Technical Writing and Communications Skills	0+1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	0+1
PGS 505	II	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Compulsory Non credit Deficiency Courses:

Students from non Bioinformatics and Biotechnology stream will be required to complete non credit deficiency courses (6 to 10 credits) from the below courses related to the discipline in which admitted and as decided by the Student Advisory Committee.

Course Number	Course Name	Credits
BI-411	Introduction to Biotechnology	2+1
BI-412	Introductory Bioinformatics	2+1
BI-413	Genomics and Proteomics	3+0
BI-414	Computational Biology	2+1
BI-415	Molecular Biology	2+1
BI-416	Molecular Genetics	2+0
BI-417	Molecular Marker Technology	2+0

Ph.D. Bioinformatics
Course Structure

LIST OF CORE COURSES/ COMPULSORY/SUPPORTING COURSES

Major courses (12 credits):(5 credits of core plus 7 credits of optional)

Course Code	Semester	Course Title	Credit
BI 601*	I	Genome wide association study	2+1
BI 602#	II	Computational analysis of Non-coding RNAs	1+1
BI 603#	I	Big data analytics	1+1
BI 604#	I	Systems Biology	3+0
BI 605*#	II	Comparative and functional genomics	1+1
BI 606	II	Phylogenetics	2+1
BI 607#	I	R and high dimensional genome data	1+1
BI 608	II	Pharmacogenomics & IPR	3+1
BI 609	I	Biological data integration and quality control	1+1
BI 610	II	Quantum theory and applications in bioinformatics	1+1
		Any other from 500 series	
BI 691*	IV	Doctoral Seminar I	0+1
BI 692*	V	Doctoral Seminar II	0+1
		Total	**16+11=27**
BI 699	IV,V, VI	Doctoral Research	0+75

*Core courses & compulsory courses; # New Courses

Minor and Supporting Courses for Doctoral degree

Minor courses:
Students will be required to complete minor courses (6 credits) from the below courses from minor disciplines.

Minor Disciplines (6 credits):

1. Molecular Biology and Biotechnology
2. Biochemistry
3. Genetics and Plant Breeding
4. Microbiology
5. Seed Science and Technology
6. Plant Physiology

Suggestive minor courses:

Followings are the list of suggestive minor courses.Students will be required to complete minor courses (6 credits) from the below courses from minor disciplines related to the major discipline in which student admitted and as decided by the Student Advisory Committee.

Course Code	Semester	Course Title	Credit Hrs.
MBB 501	I	Principles of Biotechnology	3+0
MBB 502	I	Fundamentals of Molecular Biology	3+0
MBB 517	II	Stress Biology and Genomics	2+0
BIOCHEM 501	I	Basic Biochemistry	3+1
GPB 506	I	Molecular breeding and bioinformatics	2+1
MICRO 502	I	Principles of Microbiology	3+1
PP 503	I	Plant Developmental Biology: Physiological and Molecular Basis	2+1
SST 501	II	Seed Development Biology	1+1

Supporting Courses:
Students are required to complete supporting courses of 5 credits from any of the following disciplines.

1. Statistics
2. Mathematics
3. Computer Science and Information Technology
4. Molecular Biology and Biotechnology
5. Biochemistry
6. Genetics and Plant Breeding
7. Microbiology
8. Plant Physiology

Suggested Supporting Courses (5 credits):

Followings are the list of suggestive supporting courses.Students will be required to complete supporting courses (5 credits) from the below courses and may be taken other courses from above disciplines related to the major discipline in which student admitted and as decided by the Student Advisory Committee.

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Course Contents

M.Sc.(Agri.)Bioinformatics

BI 501 Introduction to Bioinformatics and Computational Biology 2+1

Aim of the course

To provide theoretical and practical knowledge about handling and processing of genomic data, optimization and data mining techniques used in bioinformatics.

Theory

Unit I (15 Lectures)

Overview of available genomic resources on the web; NCBI/ EBI/ EXPASY etc; Nucleic acid sequence databases; GenBank/EMBL/DDBJ; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms: Needleman and Wunsch, Smith and Waterman; BLAST, FASTA; Scoring matrices for Nucleic acids and proteins: PAM, BLOSUM, Multiple sequence alignment: PRAS, CLUSTALW. Sequence based gene prediction and its function identification.

Unit II (5 Lectures)

Preprocessing of gene expression data; Data Normalization techniques, Dataquality control: Modelling of errors, Imputation etc; High-throughput screening.

Unit III (6 Lectures)

Optimization Techniques: concept and applications, Simulated Annealing, Genetic Algorithms: *Ab initio* methods for structure prediction; Information theory, entropy and relative entropy.

Unit IV (6 Lectures)

Foundations for Machine learning Techniques: Unsupervised and Supervised Learning, Cross Validation Techniques, Markov Model, Bayesian Inference: concepts and applications, Hidden Markov Model and applications, Introduction to WEKA package.

Practicals

Database Similarity Searches, Multiple sequence alignment, Genome databases, Structural databases, Derived databases, Gene annotation, Gene prediction software. Analysis of DNA microarray experiments, Expression profiling by

microarray/gene chip, Proteomics, Pattern recognition, Hidden Markov Models, Gibbs Sampling, Analysis of single and multiple DNA or protein sequences.

Suggested Reading:

- Baldi, P. and Brunak, S. 2001. *Bioinformatics: The Machine Learning Approach*. MIT Press.
- Baxevanis,A.D. and Francis,B.F.2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* John Wiley.
- Wang JTL, Zaki MJ, Toivonen HTT and Shasha D. 2004. Data Mining in Bioinformatics. Springer.
- Amaratunga D and Cabrera J. 2004. *Exploration and Analysis of DNA Microarray and Protein Array*. John Wiley.
- Gupta GK. 2006. *Introduction to Data Mining with Case Studies*. Prentice Hall of India, New Delhi.
- Han J and Kamber M. 2006. *Data Mining: Concepts and Techniques*. Morgan Kaufman.
- Hand DH, Mannila P Smyth. 2001. *Principles of Data Mining.* Prentice Hall of India, New Delhi.

BI 502	Statistical Genomics	2+1

Aim of the course

This course builds the basic understanding of statistical methods used in genetics and genomics.

Theory

Unit I (14 Lectures)

Fundamentals of Population genetics: Hardy –Weinberg law, Effect of systematic forces on changes in gene frequency; Principles of Quantitative genetics: Values, Means and Variances, Detection and Estimation of Linkage, Inbreeding, Selection, Genetic Parameter Estimation, Variance component estimation, BLUP, G x E interaction, Path Analysis

Unit II (10 Lectures)

Molecular Marker based classification: similarity measures, clustering methods, bootstrapping; QTL mapping: Detection and Estimation of QTL, Single Marker Analysis, Interval Mapping and MQM;

Unit III (8 Lectures)

Design and Analysis of Expression Data; Genome Selection; Genome Prediction, Genetic Markers, Association Mapping; Genome Wide Association Analysis

Practicals

Population genetics: Hardy-Weinberg law, Estimation of linkage, Inbreeding, Selection, Genetic parameter estimation, Variance component estimation, BLUP, Path analysis, Molecular marker based classification, Estimation of QTL, Single marker analysis, MQM, Analysis of gene expression data, Genome selection and Genome prediction.

Suggested Reading

- Xu, Shizhong. 2013. *Principles of Statistical Genomics*. Springer
- Ben Hui Liu. 1997. *Statistical Genomics: Linkage, Mapping, and QTL Analysis.*
- Sorensen D and Gianola D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.
- Ben HL and Leming MS. 2013. *Statistical Genomics and Bioinformatics.*

BI 503 Genome Assembly and Annotation 1+1

Aim of the course

The primary objective of this course is to develop practical understanding of techniques and tools used in genome assembly with emphasis on issues and challenges of its structural and functional annotation.

Theory

Unit I (6 Lectures)

Types and methods of genome sequence data generation; Shot gun sequencing method; Problems of genome assembly, Approaches of genome assembly: Comparative Assembly, DE novo Assembly; Read coverages; Sequencing errors, Sequence Quality Matrix, Assembly Evaluation; Challenges in Genome Assembly.

Unit II (5 Lectures)

Various tools and related methods of genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAP*denovo,* etc.

Unit III (5 Lectures)

Basic concepts of genome annotation; Structural and Functional Annotation; Identification of open reading frame (ORF) and their regularization, Identification of gene structure, coding regions and location of regulatory motifs.

Practicals

Genome assembly methods for data from various sequencing platform, Sequencing error determination, Sequence quality matrix; Various tools for genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAP *denovo,* etc. Structural and functional Genome annotation.

Suggested Reading

- Jung, S., Paul, Gordon, M.K., Sensen, C. W. 2012. *Genome Annotation.* Chapman and Hall/ CRC
- Venter,J.C.,2000.*AnnotationoftheCeleraHumanGenomeAssembly*.Celera.
- Mark Menor. 2007. *Multi-genome Annotation of Genome Fragments Using HiddenMarkov Model Profiles*
- Carson Hinton Holt. 2012. *Tools and Techniques for Genome*

Annotation and Analysis

- Alistair G.Rust, Emmanuel Mongin and Ewan Birney Loraine A.E and Helt G.A. 2002. *Genome annotation techniques: new approaches and challenges. Drug Discovery Today*. 570- 576p.
- Weizhong Li and Adam Godzik. 2002. *Discovering new genes with advanced homology detection. Trends in Biotechnology*, 20: 8, 315-316 p.

BI 504 Bio-molecular Modelling and Simulation 2+1

Aim of the course

The course aimed to develop understanding of bio molecular modeling techniques and simulation

Theory

Unit I (8 Lectures)

Methods for 3D Structure Prediction: Homology modeling of protein 3D structures– approaches to loop building, energy considerations and evaluation of the accuracy of the model. *ab initio* approach to 3D structure prediction; Threading approach to 3D structure prediction. A Comparison of protein structure prediction methods: CASP

Unit II (8 Lectures)

Basic principles of modeling, modeling by energy minimization technique, concept of rotation about bonds, energy minimization by basic technique for small molecules, Ramachandran plot, torsional space minimization, energy minimization in Cartesian space, molecular mechanics-basic principle

Unit III (8 Lectures)

Basic concepts of Simulation Modelling: Units and derivatives, Force field and energy landscape, Truncation of non-bonded interactions, Introduction to solvation, Periodic boundary condition, Waldsummation, implicit solvent model and continuum electrostatics, Monte Carlo simulation on parallel computers. Replica-exchange simulations, Restraint potentials, Free energy calculations, Membrane simulations

Unit IV (8 Lectures)

Energy Minimization: Concept of energy minimization - hypersurface, local and global energy minima, statement of problem. Derivative minimization methods – first derivative methods: the steepest descents method, line search in one dimension, arbitrary step approach, conjugate gradients minimization. Second derivative method – the Newton-Raphson method. Applications of energy minimization.

Practicals

Protein structure databases: PDB, MODBASE, Structure visualization – Rasmol and PyMol, Structural analysis- classification, CATH, SCOP, Protein geometry – bond length, bond angle, torsion angle, calculation of surface area, volume and

radii: Swiss PDB Viewer. Small molecule generation - peptides and nucleic acids: ISISdraw/ChemSketch,Selectionofquerysequence,templateselection:pdbBLAST, Comparative 3D structure prediction – SWISSMODEL, Model generation - building side chains and loops using Modeller, Threading, *ab initio* modeling, Structure validation - generation and analysis of Ramachandran plot using PROCHECK, WHATCHECK via SAVS server, Force field calculation and energy minimization, Structure refinement- loop building, removing non-bonded contacts, adding missing side chains via WhatIf interface, Scoring structural similarity - 3D structure alignment - RMS superimposition – VMD, Molecular dynamics simulation using Tinker. Simulation dynamics, Montecarlo simulation on parallel computers. Replica exchange simulation, free energy calculation. Docking

Suggested Reading:

- Schlick T. 2010. *Molecular Modeling and Simulation: An Interdisciplinary Guide*. Science.
- Gunsteren WF, Weiner PK, Wilkinson AJ. 1997. *Computer Simulation of Biomolecular Systems: Theoretical and experimental application*. Springer.
- Martin JF.2007. *A Practical Introduction to the Simulation of Molecular Systems*. Cambridge University Press.
- Leach AR. 2001. *Molecular Modeling: Principles and Applications*. Prentice Hall.784p.
- Marx D and Hutter J. 2009. *Ab Initio Molecular Dynamics: Basic Theory and Advanced Methods*. Cambridge University Press.578p.

BI 505 Transcriptomics and Metagenomics 2+1

Aim of the course

The course aims to teach basic concepts of metagenomics and various techniques used in the analysis of metagenomic data

Theory

Unit I (8 Lectures)

Microarrays, RNA-seq, Chip-Seq, EST-clustering, differential expression analysis

Unit II (6 Lectures)

Taxonomic and genetic annotation of high throughput sequence data, microbial diversity analyses, analyses of microbial community composition and change and metabolic reconstruction analyses.

Unit III (9 Lectures)

Comparison between Metagenomics and AL, EC, Comparison between LCS and Metagenomics, Symbiotic Evaluations: SANE, Comparison between SANE and Metagenomics, Horizontal Gene Transfer: Microbial GA.

Unit IV (9 Lectures)

Metagenome Sequencing, Single Cell Analysis, Host-Pathogen Interaction; Shotgun metagenomics; High-throughput sequencing; Comparative metagenomics; Community metabolism; Metatranscriptomics.

Practicals

Meta genome annotation, Analyses of microbial community composition and change and metabolic reconstruction analyses; Metatranscriptomics; Comparative metagenomics. Microarray data analysis; RNA-seq, chip-seq, EST-clustering.

Suggested Reading

- Diana Marco. 2010. *Metagenomics: Theory, Methods and Applications*. Ceister academic press
- Streit WR and Daniel R. 2010. *Metagenomics: Methods and Protocols*. Springer protocols.
- Yeh WK, Yang H, McCarthy JR. 2010. *Enzyme Technologies: Metagenomics, Evolution, Biocatalysis and Biosynthesis*. Wiley
- Muthukumar V.2003. *Metagenomics for the Identification of Plant Viruses*. Pro Quest.

BI 506 Biological Data Management 2+1

Aim of the course

The course aims at teaching database management system and familiarizing with the techniques of data sources, data curation and integration of data sources.

Theory

Unit I (6 Lectures)

Database Management System (DBMS): Need for DBMS - File system vs Database system, Advantages of DBMS - DBMS Architecture – DBMS services - Data abstraction - Overview of Data Models: Hierarchical Model - Network Model - Entity-Relationship (E-R) Model: Symbols - Components of E-R Model: Entities, Attributes, Relationships - Relational Model, Object-oriented Model.

Unit II (8 Lectures)

Overview of Relational Database Objects – Relation – Tuple - Cardinality – Attribute – Degree - Domain - Primary key – Foreign key - Relational data structure – Relational Data Integrity and Constraints: Domain constraints, Entity integrity, Referential Integrity, Operational constraints - Codd's Rules – Normalization: 1NF, 2NF, 3NF, BCNF, 4NF and 5NF.

Unit III (8 Lectures)

Structured Query Language (SQL): Overview of SQL – SQL Data types and Literals

– SQL Commands: Data Definition Language (DDL), Data Manipulation Language (DML), Data Querying Language (DQL), Data Control Language (DCL), Data Administration Statements (DAS), Transaction Control Statements (TCS), SQL Operators: Arithmetic, Comparison, Logical and Set Operators–SQL Query, Nested Query-SQL Aggregate functions.

Unit V (10 Lectures)

Curation of genomic, genetic, proteomic data, High-throughput screening, array, qPCR data sets; Quality management of data: tools and techniques. Biological data sources, Data granularity, Schema modelling, architecture, query design, extraction, transformation and loading, Long term data management, storage and security. Bio-chip information system, visualization and reporting, Risk factors for data quality management. Un-structured or noSQL database; AI and BIG data Analytics

Practicals

Understanding the data sources, Data granularity, Data modeling and architecture, development of database, Storage, Security, Visualization and reporting.

Suggested Reading

- Kozak K.2010. Large scale data handling in biology. Ventus Publishing ApS.ISBN978-87- 7681-555-4.
- Harold, E. and Means W.S. 2004. XML in a Nutshell, Third Ed. O' Reilly, Sebastopol, CA
- Witten, I.H. and Frank E. 2005. Data Mining: Practical Machine Learning Tools and Techniques (WEKA), 2nd Ed. San Francisco, Morgan Kaufmann,
- Lodish, H. et al. 2000. Molecular cell biology. New York: Freeman & Co.
- Kaneko K. 2006. Life: An Introduction to Complex Systems Biology. Springer.

BI 507 Biological Network Modelling and Analysis 2+1

Aim of the course

This course aims to develop basic understanding of system biology through biological network modelling and its analysis.

Theory

Unit I (12 Lectures)

Introduction to biological networks, Graph theoretic modelling and analysis of biological networks, Discrete Dynamic modelling (Boolean networks, Petri nets), Continuous dynamic modelling (ODEs, stochastic simulation, etc.)

Unit II (12 Lectures)

Probabilistic modeling (Probabilistic Boolean networks, Bayesian networks, Mutual Information), Network inference from experimental data, Genome-scale modelling and network integration

Unit III (8 Lectures)

Evolutionofmolecularnetworks,Network-guidedGWASstudies,FBAandepistasis detection, protein function prediction

Practicals

Biological networks, Graph theoretic modelling and analysis of biological networks, Discrete Dynamic modeling; Continuous dynamic modeling; Probabilistic modeling; Genome-scale modelling and network integration; Evolution of molecular networks, Network-guided GWAS studies, FBA and epistasis detection, protein function prediction.

Suggested Reading

- Junker BH. 2008. *Analysis of Biological Networks*.
- Koch I Reisig, W. Schreiber F. 2010. *Modeling in Systems Biology: The Petri Net Approach*.
- Ramadan EY. 2008. *Biological Networks: Modeling and Structural Analysis*.
- Laubenbacher R. 2007. *Modeling and Simulation of Biological Networks.*

BI 508 Computer Programming in Bioinformatics 2+1

Aim of the course

To learn programming skills for parsing biological data, parallel computing, database connectivity and web-interface.

Theory

Unit I (7 Lectures)

BioJava- Packages, Data Import, Manipulation; Python- Basic Syntax, Loops, Functions; BioPython.

Unit II (7Lectures)

Bioperl: Introduction, Modules: SeqIO, SearchIO, Seq Feature, Finding introns, Alignments, LiveSeq and Tree.

Unit III (12 Lectures)

OpenMP: Clauses, Work sharing constructs, Synchronization constructs, Environment variables, Global Data, Runtime functions, Message Passing Interface (MPI): Introduction and programming, Point to point communications, Collective communications, Advanced MPI1 concepts, MPI2 introduction, Hybrid (openMP + MPI) programming.

Unit IV (6 Lectures)

Compute Unified Device Architecture (CUDA): Introduction and Programming, GPU computing.

Practicals

BioPerl programming using bioperl modules such as SeqIO, SearchIO, LiveSeq and Tree; OpenMP programming on Work sharing and Synchronization constructs, Environment variables and global data; MPI programming on Point to point communications and Collective communications; Compilation of OpenMP and MPI programs; Execution of OpenMP and MPI programs; Use of high performance computing, computing resources and job scheduling.

Suggested Reading

- Tisdall J. 2001. *Beginning Perl for Bioinformatics*.O-Reilly.
- Schwartz RL, Phoenix T, Foy BD. 2008. Learning Perl.O-Reilly.
- Orfali R and Harkey H. 1999. *Client/Server Programming with JAVA and CORBA*. John Wiley.

- Sriram Srinivasan. 1997. *Advanced Perl Programming*.O-Reilly.
- Bunce T and Descartes A. 2000. *Programming the Perl DBI*.O-Reilly.
- Mitchell L Model. 2010. *Bioinformatics Programming Using Python*, O'Reilly media, Cambridge, Bal HP 2003. *Perl Programming for Bioinformatics*, Tata McGrawHill.

BI 509 Machine Learning Techniques in Bioinformatics 2+1

Aim of the course

The purpose of the course is to explain various machine learning techniques and its applications on biological data.

Theory

Unit I (10Lectures)

Introduction to statistical learning theory, Empirical Risk Minimization, Structural Risk Minimization; Classification: Decision tree, Bayesian, Rule based classification, ANN, SVM, KNN; Case based reasoning and Applications in Bioinformatics.

Unit II (12 Lectures)

Clustering: Partition Methods, Heirarchical methods, Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering, Analysis of MD trajectories, Protein Array data Analysis.

Unit III (10 Lectures)

Dimensional Reduction Techniques, Methods of Feature Selection, Resampling Techniques, Elements of Text Mining and Web Mining, Soft Computing and Fuzzy logic system and application in bioinformatics.

Practicals

Decision tree, classification techniques: ANN, SVM, KNN, Case based reasoning and its applications on biological data. Clustering techniques; Clustering of high dimensional data; Dimensional reduction techniques; Resampling techniques; Text mining and Web mining. Soft Computing and Fuzzy logic system & application in bioinformatics.

Suggested Reading

- Witten, H.I., Frank, E. and Hall, M.A. 2011. *Data Mining: Practical Machine Learning Tools and Techniques*.
- Hastie, T., Tibshirani, R., Friedman, J.H. 2009. *The Elements of Statistical Learning: DataMining Interface and Prediction*.
- Clarke, S.B., Fokoue, E. and Zhang, H.H. 2009. *Principles and Theory for Data Mining and Machine Learning*.

Course Contents

Ph.D. (Agri) in Bioinformatics

BI 601	Genome Wide Association Study	2+1

Aim of the course

To introduce the concepts, principles, various designs and techniques of genome wide association study.

Theory

Unit I (12Lectures)

Definition, Allelic spectra of common diseases, Allele frequencies for susceptibility loci, Risks associated with disease-susceptibility variants, Applications of linkage- disequilibrium metrics, SNP map, Genomere sequencing for full coverage in genome- wide association studies, Transmission Disequilibrium Test, common variant hypothesis, rare allele hypothesis, Genome-wide graph theory algorithms

Unit II (12 Lectures)

Case-Control design, Trio design, Cohort design, Cross-sectional designs for GWAS Selection of Study Participants, Environmental confounders in GWAS, Confounding by population stratification, Genotyping and Quality Control in GWA Studies, Analysis of association between SNP and traits.

Unit III (8 Lectures)

Uses of GWAS: gene-gene interaction, detection of candidate haplotypes, association between SNPs and gene expression.

Practicals

Allelic spectra of common diseases, Allele frequencies for susceptibility loci, linkage- disequilibrium metrics, SNP map, Genome resequencing for full coverage in GWAS; Case-Control design, Trio design, Cohort design, Cross-sectional designs for GWAS Selection; Genotyping and Quality Control in GWA Studies; Analysis of association between SNP and traits.

Suggested Reading:

- Qin H. 2008. *Statistical Approaches for Genome-wide Association Study and Microarray Analysis*.

- Yang C. 2011. *SNP Data Analysis in Genome-wide Association Studies*.
- Kraft JS. 2010. *Genome-wide Association Study of Persistent Developmental Stuttering*.

BI 602 Computational analysis of Non-coding RNAs 1+1

Aim of the course

To introduce non-coding RNAs, its role and regulation in model organisms and tools and methods for *in silico* analyses.

Theory

Unit I (8 Lectures)

Course overview; RNA molecules: biogenesis, types, structure and functions. Introduction to ncRNAs: types of ncRNAs, small ncRNAs, long ncRNAs, function of ncRNAs, Role of ncRNAs in plants and animals

Unit II (6 Lectures)

Small ncRNA**:** Introduction, miRNAs, siRNAs, hnRNAs, piRNAs, shRNAs; Post-transcriptional processing of microRNA; microRNA: target pairing and RISC function; miRNA target genomics; Functions and roles of miRNAs in growth & development of plants and animals. Stress responsive miRNAs, on comiRs & tumour suppresser miRNAs. MiRNA Databases: miRBase, miRVIT

Unit III (6 Lectures)

lncRNAs: biogenesis, classifications, structure and function of lncRNAs. Endogenous target mimic IncRNAs, triplet associated IncRNAs (miRNA, mRNA, IncRNAs); Circular RNAs: structure and functions. Role of circular RNA in cancer, growth and development.

Unit IV (6 Lectures)

Splicing and splice variants; Alternative splicing; Alternative splicing regulation; Nonsense mediated RNA decay; RNA editing.

Unit-V (6 Lectures)

Coding and non-coding sequences; TEs; lincRNAs and lncRNAs; Bacterial RNAs; riboswitches; Introduction to CRISPRs and application of CRISPR in modern genomics

Practicals

Exploration of databases and tools for identification and characterization of ncRNAs (miRNA, IncRNAs, circular RNAs); Prediction and characterization of ncRNAs from RNA-seq data; Structure prediction and validation of ncRNAs; Generation of new ncRNA resources and submission to genomic databases.

Suggested Reading

- Ernesto Picardi Eds. 2015. *RNA bioinformatics*. Springer
- Ruzyo,G.J.,andWalter,L.,(Eds.)2014.*RNA sequence, structure and function: computational and bioinformatic methods*–Springer
- Krebs, J. E., Lewin, B., Goldstein, E. S., Kilpatrick, S. T., 2014. *Lewin's Genes XI*- Jones & Bartlett Publishers
- MRS Rao. (ed.). 2017. *Long non-coding RNA biology*, Springer
- Darnell J. 2011. *RNA: Life's indispensable molecule* – CSH Press
- Krishnarao A. 2008. *MicroRNA-from basic science to disease biology*-Cambridge Univ Press.

BI 603	Big Data Analytics	1+1

Aim of the course

To introduce concepts of Big Data, Handling of unstructured genomic data using Bigdata analytics based tools.

Theory

Unit I (5 Lectures)

Big Data- Concepts, characteristics and relevance; MapReduce – Algorithm and application. Programming Models for Big Data.

Unit II (3 Lectures)

Hadoop framework, Hadoop Distributed File System (HDFS), YARN.

Unit III (5 Lectures)

BigDataSQL:–HiveDataDefinitionLanguage,HiveDataManipulationLanguage, Hive Analytics: RegexSerDe,Views.

Unit IV (3 Lectures)

Apache Spark: Spark SQL, Spark DataFrame; PIG

Practicals

Hadoop environment setup, HDFS, Spark SQL, Hadoop MapReduce, YARN, Hive, PIG.

Suggested Reading

- Zikopoulos, P. C., Eaton, C., DeRoos, D., Deutsch, T., and Lapis, G. 2012. *Understanding big data: Analytics for enterprise class hadoop and streaming data* (p. 176). New York: Mcgraw-Hill.
- Gandomi, A., and Haider, M.2015. *Beyond the hype: Big data concepts, methods, and*
- *analytics*. *International Journal of Information Management*, *35*(2), 137-144.
- Akerkar R. (Ed.). 2013. *Big data computing*. CRC Press.
- Prajapati,V.2013.*Bigdata analytics with R and Hadoop*. Packt Publishing Ltd.

BI 604	Systems Biology	3+0

Aim of the course

This course provides emphasis on synthetic biology, modeling of genetic networks, cell-cell interactions, and evolutionary dynamics.

Theory

Unit I (16Lectures)

Basic concepts in networks and chemical reactions; Input function of a gene, Michaelis-Menten kinetics, and cooperativity; Autoregulation, feedback and bistability; Introduction to synthetic biology and stability analysis in the toggle switch; Oscillatory genetic networks, Graph properties of transcription networks, Feed-forward loop network motif.

Unit-II (8 Lectures)

Introduction to stochastic gene expression, Causes and consequences of stochastic gene expression, Stochastic modeling—The master equation, Fokker-Planck Equation, and the Gillespie algorithm

Unit III (12 Lectures)

Introduction to microbial evolution experiments, and optimal gene circuit design, Evolution in finite populations, genetic drift, and the theory of neutral molecular evolution; Clonal interference and the distribution of beneficial mutations, Fitness landscapes and sequence spaces.

Unit IV (12 Lectures)

Evolutionary games; Survival in fluctuating environments, Parasites, the evolution of virulence and sex; Interspecies interactions, the Lotka-Volterra model, and predator-prey oscillations; Ecosystem stability, critical transitions, and the maintenance of biodiversity; Dynamics of populations in space, The neutral theory of ecology.

Suggested Reading

- Alon, Uri. 2006. *An Introduction to Systems Biology: Design Principles of Biological Circuits*. Chapman & Hall / CRC. ISBN:9781584886426.
- Nowak,M.A.2006.*Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press, ISBN: 9780674023383.
- Bruce A. 2009. *Essential Cell Biology*. Garland Science, ISBN:9780815341291.

- Strogatz, Steven H. 2014. *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*. Westview Press, ISBN:9780813349107.
- L.AlberghinaH.V.Westerhoff, 2005.*Systems Biology: Definitions and perspectives* Springer.
- A. Kriete, R. Eils,. 2014. *Computational systems biology* Second edition, Academic Press
- E.Klipp R.Herwig, A.Kowlad, C.Wierling and H.Lehrach 2005. *Systems Biology in practice: Concepts, Implementation and applications*, Wiley Inter Science.
- Pengcheng Fu, Panke S. 2009. *Systems Biology and Synthetic Biology* Wiley Inter Science.
- Rigoutsos I. and G. Stephanopoulos G. 2007. *Systems Biology* Vol.1: Genomics Oxford University Press Inc., USA.
- Choi S. 2007. *Introduction to Systems Biology*. Humana press Inc, New Jercy, USA.
- A.Kriete, R. Eils 2014. *Computational Systems Biology* (Second edition) Academic Press.

BI 605 Comparative and Functional Genomics 1+1

Aim of the course

This course provides emphasis on functional elements and advances in genomics.

Theory

Unit 1 (8 Lectures)

Functional elements, Chromosomes and transposons, Organellar Genomes, Symbiosis, Horizontal gene transfer, Gene duplication, Ploidy, Gene fates, Pan and core genomes, Recombination, Gene clustering, SNPs and HapMaps, GWAS. Comparative methods for detection of species / organism relationships, Domain evolution, Study of co-evolution: Plant-insect interactions. Host-parasite interactions, viral evolution.

Unit II (8 Lectures)

Pre-and post-genomic era; major advancements in genomic approaches; epigenetics and metagenomics; forward versus reverse genetics, Genome editing approaches and their applications; gene expression analyses and applications. RNAi. DNA chips and their use in transcriptome analysis, qPCR, SAGE, MPSS. Connecting Traits to Genes, and Genes to Functions; protein-protein interaction, and protein networks, Genome databases and annotation.

Practicals

Getting started on the HPC, Basic UNIX commands for genomics data analysis, MUMmer, Regular expressions, Unix and basic sequence statistics Databases, Genome browsers, Blast & HMMER, Short sequence alignments, Synteny analysis, Distance trees, Maximum likelihood trees, Whole Genome Alignments, DotPlots, CoGeWebTool, Anti SMASHWebTool

Suggested Reading

- Brown TA. 2006. *Genomes. 3rd edition. Garland Science*, New York.
- Sankoff D and Nadeau JH. 2000. *Comparative Genomics: Empirical and Analytical Approaches to Gene Order Dynamics, Map Alignment and the Evolution of Gene Families*. Netherlands, Kluwer Academic Publisher
- Jonathan Pevsner. 2009. *Bioinformatics and Functional Genomics*.

Wiley Blackwell

- Wilkins MR, Williams KL, Appel RD, Hochstrasser DF. (Eds) 1997. *Proteome Research: New Frontiers in Functional Genomics*. Springer Verlag Berlin Heidelberg
- Gupta PK and Varshney RK. 2009. *Cereal genomics.*
- Grotewold E.2006. *Plant Functional Genomics. Methods in Molecular Biology.* Vol 236.
- Azuaje F and Dopazo J. 2005.*Data Analysis and Visualization in Genomics and Proteomics*. John Wiley & Sons, US
- Primrose S.B and Twyman R. 2003. *Principles of Genome Analysis and Genomics*. Third Edition.
- Baxevanis.A.D.and Ouellette.B.F.F.(Eds). 2001. *Bioinformatics: A Practical guide to the analysis of genes and proteins*. Wiley Interscience. New York. 470p.
- Hunt and Livesey. 2000. *Functional Genomics: A Practical Approach*. Oxford University Press.
- Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*.Birkhäuser.
- Branden. C and J. Troze. 1999. *Introduction to Protein Structure*. SecondEdition.
- Brown TA. 2002. *Genomes* IInd Edition. Oxford Wiley Press (ISBN-10: 0-471-25046-5)
- Yun Bi Xu.2009.*Molecular Plant Breeding*. CABI (ISBN:978184593392)

BI 606	Phylogenetics	2+1

Aim of the course

To find out the evolutionary relationship among various species by using different phylogenetic techniques and algorithms.

Theory

Unit I (14Lectures)

Phylogenetic trees and their comparison: Definition and description, various types of trees; Consensus (strict, semi-strict, Adams, majority rule, Nelson); Data partitioning and combination Tree to tree distances, similarity; Phylogenetic analysis algorithms: Maximum Parsimony, Distance based: UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining.

Unit II (18 Lectures)

Probabilistic models of evolution, Maximum likelihood algorithm; Approaches for tree reconstruction: Character optimization; delayed and accelerated transformation, Reliability of trees, Bootstrap, jackknife, decay, randomization tests; Applications of phylogeny analyses: Comparison of Phylogenetic Trees obtained using DNA seq. vs. protein seq. vs. Full genomes. Need for addition of other properties towards total phylogenetic analysis

Practicals

Different software for phylogenetic tree construction and evolution of tree such as EMBOSS, MrBayes, PAUP, PHYLIP, PAML, MEGA 11, iTOL, TREE puzzle, Dendogram, cladogram analysis.

Suggested Reading

- Hall, B. G. 2001. *Phylogenetic Tress Made Easy: A How to Manual for Molecular Biologists*. Sinauer Ass., USA.
- Nei, M. and Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.
- Sankoff, D. & Nadeau JH. 2000. *Comparative Genomics: Empirical and Analytical Approaches to Gene Order Dynamics, Map Alignment and the Evolution of Gene Families*. Netherlands, Kluwer Academic Publisher
- Gustavo Caetano. 2010. *Evolutionary Genomics and Systems Biology*. Wiley-blackwell.

- Mount.D.W.2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press. New York. 564pp.
- Nei M and Kumar S.2000. *Molecular Evolution and Phylogenetics* Oxford University Press.
- Engels J.M.M, Ramanatha Rao.V, Brown.A.H.D and Jackson.M.T, 2002. *Managing Plant Genetic Diversity*, CABI Publishers, CAB International UK489pp.

BI 607 R and High Dimensional Genome Data 1+1

Aim of the course

This course mainly aims at teaching R and its packages, programming to the students and make them acquainted with the use of R for data analysis, in general, and genomic data analysis, in particular.

Theory

Unit I (8 Lectures)

R programming language: Introduction and basics, R data types-Arithmetic and Logical Operators. R Matrix- Create, Print, add Column, Slice; R Data Frame- Create, Append, Select, Subset, Sort; List in R- Create, Select; R Functions; If, Else, Else If statements in R; For loop and While Loop in R; Data Importing and Exporting; Correlation, Anova, T test , Simple and Linear Regression, Scatter Plot, Bar Chart and Histogram in R; Memory management;

Unit II (8 Lectures)

Applications of R: Univariate and Multivariate phenotypic data analysis; Linear Models – fixed effects model, random effects model, mixed effects model for genetic parameter estimation; GGE Biplot and AMMI for Stability analysis; Gene Expression analysis–Microarray and RNA-Seqdata; Genome Wide Association Study (GWAS), Genomic Selection (GS), Sequence analysis; Genome Assembly and Annotation; Machine Learning–ANN, SVM, Random Forest, Deep Learning.

Practicals

Matrix Operations In R; R Data Frame, Functions in R, Correlation in R, Simple and Linear Regression in R. ANOVA in R, Other applications of R for crop and animal improvement.

Suggested Reading

- Ihaka R and Gentleman R.1996. *R:A language for data analysis and graphics*. *Journal of computational and graphical statistics*, *5*(3),299-314.
- Gentleman R. 2008. *R programming for bioinformatics*. Chapman and Hall/CRC.

BI 608	Pharmacogenomics and IPR	3+1

Theory

Unit I (8 Lectures)

Introduction to Drugs: Sources of drug- plant, animal, microbes, minerals. Drug name – chemical name, brand name or trade name, general name or common name. Drug classification – Chemotherapeutic agents, Pharmacodynamic agents, Miscellaneous agents. Routes of administration – Oral route and Parental route. Drug Absorption, Distribution, Metabolism and Excretion (ADME).

Unit II (8 Lectures)

Drug Response to Genetic Variations: SNP as markers in Pharmacogenomics- Turning SNPs into Useful Markers of Drug Response. Mechanism of drug action

– receptor, agonist, ion channel. Inheritance and drug response - Pharmacogenetics of drug metabolism – Phase I metabolism, Phase II metabolism. Pharmacogenomics of Drug Transporters- Organic Anion and Cation Transporter Family, Peptide Transporter Family, Multidrug Resistance-Associated Proteins.

Unit III (6 Lectures)

Case Studies in Pharmacogenomics: Pharmacogenomics of Chemotherapeutic Agents in Cancer Treatment, Pharmacogenomics of Neurodegenerative Diseases: Examples and Perspectives, Pharmacogenomics of Alcoholism, Ethnicity and Pharmacogenomics. Ayugenomics. Pharmacogenomics and pharmaceutical Industries.

Unit IV (8 Lectures)

Basics of Toxicogenomics: Definition, genetic polymorphisms, Comparative toxicogenomics database (CTD) – Chemical gene interaction, chemical – disease association, gene – disease association. Specific applications of toxicogenomics – xenobiotics – insecticide - exposure assessment, hazard screening, variability of susceptibility, mechanistic information, cross-species extrapolation, dose-response relationship, development exposures, mixture.

Unit V (6 Lectures)

Databases for Toxicogenomics: Sample collection and data uniformity. Sharing and distributing data. Building toxicogenomic databases. Toxicogenomic Data Repositories–Standardization, availability, transparency. Data repositories-Stanford Microarray Database, CaBIG, Drug Matrix database, Tox-Express.

Unit VI (12 Lectures)

WTO and TRIPS Agreement: World Trade Organization (WTO)-Globalization-Trade Related Intellectual Property Rights (TRIPs) -General Obligations–substantive requirement of the TRIPS agreement in the WTO –International Union for the Protection of New Varieties of Plants (UPOV)- Multilateral treaties on patent Forms of IPR and Role of Institutions: Different forms of IPR-Patents, Copyrights, GIs, Trademarks, Industrial Designs and Layouts, Trade secrets – Types of IPR forms-Utility, Design and plant patents, Generic and descriptive trademarks Role of Indian Patent Office (IPO), National Association of Creators, Owners and Users of Intellectual Property **(**NIPO), Geographical Indications (GI) registry-Multilateral organizations- World Intellectual Property Organization (WIPO), European Patent Office (EPO), US Patent and Trademark Office (USPTO), Biotechnology and IP Rights: Biotech market in India-Biotech: SWOT – Bioinformatics in India – patent claims in biotechnology – patentable and non- patentable biotech inventions-patenting microorganisms and GMOs-Utility patents for genetic materials-patenting of biotech research tools - Types of bioinformatics patents -Infringement laws at National and International level- Acquisition / licensing of bio-tech patents and trade secrets. IP Issues in Biotech Research and Development: Research and Development in Biotechnology - Biotechnology and seed policy- Role of Multi-national and Domestic Seed Firms- Moral issues in Patenting Biotechnological inventions-Bio-safety and Bioethics- International bio-safety protocols-cartegena protocols. IPinIndianAgriculture:Sui-generissystemandStatusofplantvarietiesprotection in India- Protection of plant genetic resources- protection of Bio-diversity in India-Protection of GIs.

Practicals

Literature resources: selection and study on a disease, Identification of receptor and ligand involved, search on the drugs at practice, mechanism of their action, toxicity issues-using search engines, Databases on Toxicogenomics-KEGG, chemical databases- Chemfinder, ADME databases, Identification of pharmacophores using databases- retrieving their properties, structure in Smiles notation using Pubchem/ drug bank. Conversion of SMILES, SYBYL, MOL files to PDB format- CORINA, conversion of coordinate file to topology formats- prodrg server, Small molecule generation, evaluation and optimization using Chemsketch, Comparative gene expression analysis on normal and diseased condition, A study on ADME properties- ADME database, calculation of ADME properties- Lipinski rule – Molinspiration tool, High throughput

assay to determine a drug toxic effect- ADMEtox, Structural analysis of Protein and Pharmacophores; structural alignment, structural properties- Rasmol/ SPDBV, Study of instruments used in experimental Pharmacology, smoking and fixing a kymograph - Handling of laboratory animals - Techniques of drug administrations in animals - Influence of route of administration of drugs on drug response.

Suggested Reading

- QingYan. 2006. *Pharmacogenomics in Drug Discovery and Development*. Humana Press.
- Licinio, J., and Wong, M.L. 2002. *Pharmacogenomics: The Search for Individualized Therapies*. Wiley-VCH, Verlag GmbH.
- Burcznski, M. E. 2003. *An Introduction to Toxicogenomics*. CRC Press.
- Catania MG.2005. *An A-Z Guide to Pharmacogenomics*, AACC Press.
- Kille P. 2008. *Comparative Toxicogenomics*. Christer Hogstrand. Elsevier Science
- Erbisch FH and Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Anonymous.2004. *State of Indian Farmer*. Vol.V. Technology, Ministry of Agriculture, Government of India.
- Rothschild M and Scott N. (Ed.). 2003. *Generation and IPR Issues*. Academic Foundation.
- B.L.Wadera. 1996. *Patents, Trade Marks, Copy Right Designs & Geographical Indications*. Universal Law Publishing Co.Pvt.Ltd.
- Narayana PS.2004. *Intellectual Property Law in India*. K.C.Gogia, M/S Gogia Law Publication.
- Ganguli P. 2008. *Intellectual Property Rights: Unleashing Knowledge Economy*, McGraw Hill, New Delhi
- Santaniello V, Evenson RE, Zilberman D, Carlson GA. 2000. *Agriculture and Intellectual Property Rights: Economic, Institutional and Implementation Issues in Biotechnology*, CABI Publishing, Wallingford, UK

BI 609 Biological Data Integration and Quality Control 1+1

Aim of the course

To familiarize the techniques of data sources, data curation and integration of data sources

Theory

Unit I (5 Lectures)

Curation of genomics, genetic, proteomics, High-throughput screening, array, qPCR data sets; Quality management of data: tools and techniques.

Unit II (6 Lectures)

Biological data sources, Data granularity, Schema modelling, architecture, query design, extraction, transformation and loading, Long term data management, storage and security.

Unit III (5 Lectures)

Bio-chip information system, visualization and reporting, Risk factors for data quality management.

Practicals

Understanding the data sources, Data granularity, Data modeling and architecture, development of database, Storage, Security, Visualization and reporting.

Suggested Reading

- Kozak, K.2010. Large Scale Data Handling in Biology. 2010. Ventus Publishing ApS. ISBN 978-87-7681-555-4.
- Harold, E. and Means W.S.2004. *XML in a Nutshell*, Third Ed. O'Reilly, Sebastopol, CA
- Witten, I.H. and Frank E. 2005. *Data Mining: Practical Machine Learning Tools and Techniques* WEKA, 2nd Ed. San Francisco, Morgan Kaufmann
- Lodish, H. *etal*. 2000. *Molecular Cell Biology*. New York: Freeman & Co.
- Kaneko K. 2006. *Life: An Introduction to Complex Systems Biology*. Springer.

BI 610 Quantum Theory and Applications in Biology 1+1

Aim of the course

This course introduces the concepts of quantum theory with application in molecular biology

Theory

Unit I (5 Lectures)

Classical mechanics, Newton, Lagrange and Hamilton's equations, Schrodinger's equation and its complete solution for S.H.O, central force and angular momentum

Unit II (6 Lectures)

Atomic orbital models, the wave equation, molecular orbitals, the LCAO method, the overlap method, coulomb and resonance integrals, the hydrogen molecule, charge distributions, approximate methods

Unit III (5 Lectures)

Absorbance of frequency-specific radiation (photosynthesis), Conversion of chemical energy into motion, Magneto reception in animals, DNA mutation and Brownian motors in many cellular processes

Practicals

Classical mechanics, Central force and angular momentum; Atomic orbital model, Wave equation, Resonance integers. DNA mutation and Brownian motors in many cellular processes.

Suggested Reading

- Heisenberg W. 1949. *The Physical Principles of the Quantum Theory*.
- Bohm D. 1951. *Quantum Theory*.
- Ghatakm AK and Lokanathan S. 2004. *Quantum Mechanics: Theory and Applications.*
- Bittner ER. 2009. *Quantum Dynamics: Applications in Biological and Materials Systems*.
- Blinder SM. 2004. *Introduction to Quantum Mechanics: In Chemistry, Materials Science, and Biology.*

List of Journals

- *Journal of Plant Bioinformatics and Biotechnology*
- *Plant Sciences Journal*
- *Bioinformatics*
- *Journal of Computational Biology*
- *Briefings in Bioinformatics*
- *In Silico Biology*
- *Structure*
- *Protein Science*
- *Protein Engineering*
- *Proteomics*
- *Nucleic Acids Research*
- *Trends in Biotechnology*
- *Folding and Design*
- *Genome Biology*
- *Bioinformation*
- *Journal of Computational Intelligence in Bioinformatics*
- *Journal of Structural and Functional Genomics*
- *Journal of Molecular Graphics and Modelling*
- *Metabolic Engineering*
- *Computers & Chemistry*
- *Artificial Intelligence in Medicine*
- *Applied Bioinformatics*
- *Applied Genomics and Proteomics*
- *BMC Bioinformatics*
- *Online Journal of Bioinformatics (OJB)*
- *Bioinformatics: Information Technology & Systems (BITS)*
- *Data Mining and Knowledge Discovery*
- *The EMBO Journal*
- *Current Opinions in Structural Biology*
- *Journal of Molecular Microbiology and Biotechnology*
- *Nature*
- *Nature Structural Biology*
- *Nature Genetics*
- *Current Opinion in Genetics & Development*
- *Nature Biotechnology*
- *Trends in Biochemical Sciences*

- *Proteins: Structure, Function, and Genetics*
- *Nature Cell Biology*
- *Trends in Genetics*
- *Journal of Molecular Modelling*
- *Trends in Pharmacological Sciences*
- *Drug Discovery Today*
- *Annual Review of Biochemistry*
- *Annual Review of Genetics*
- *Annual Review of Plant Physiology and Plant Molecular Biology*
- *Current Science*
- *Indian Journal of Experimental Biology*
- •*Journal of Immunology*
- *Journal of Molecular Modelling*
- *Journal of Plant Biochemistry and Biotechnology*
- *Nature*
- *Physiologia Plantarum*
- *Plant Physiology*
- *Plant Science*
- *Planta*
- *Proceedings of National Academy of Sciences, USA*
- *Protein Science*
- *RNA*
- *Science*
- *Scientific American*
- *Trends in Biotechnology*
- *Trends in Plant Sciences*

Restructured and Revised Syllabi of Post Graduate Programmes

M. Sc. and Ph. D. (Agriculture) in Molecular Biology and Biotechnology

Compiled by

Broad Subject Co-ordinator

Associate Dean and Principal
Vilasrao Deshmukh College of Agricultural Biotechnology, Latur,
VNMKV., Parbhani

Discipline Coordinator
Officer Incharge,
Biotechnology Centre, Dr. PDKV., Akola

CONTENTS

PREAMBLE

The tremendous impetus received for biotechnological research and education has been due to its direct impact on human and animal health, agricultural productivity, and environment issues. At present in India the number of companies involved in R&D or product development, or production related to biotechnology and life sciencesproducts has grown enormously. To sustain these efforts, biotechnology R&D as well as education sector needs high quality human resources for inventing and creating value added products through intervention of biotechnology. This has created requirement of highly skilled manpower equipped with biotechnological as well as information technology skills to analyze, annotate and make use of the genetic information for genetic enhancement of crops. This fact has gained importance in the recent time not only from industrial point of view but also from basic and strategic future research. Major interest and scope of Biotechnology has emerged from the techniques which permit manipulation of biological systems in a defined and deliberate manner for beneficial purposes. In view of the fast-expanding scope of Biotechnology, the post graduate programme, non- existent a few decades ago is now being offered in hundreds of public and private universities and institutes. Several agricultural universities offer Biotechnology programmes, and there is strong need for continuous faculty competence improvement, for updating skill and knowledge of scientists through national and international human resource development activities and programmes.The contents of most of the courses in PG degree programmes have been revised keeping in view the advances in the respective subject area. The new curricula and syllabi have increased practical component to provide hands on training and analytical skills to the students. The practical exercises have been distinctly out lined in the courses as these are to be conducted rather than in descriptive running text. Such courses are aimed at strengthening the practice/practical skills of the students to equip the students with modern research skills and knowledge to meet requirements of R&D organizations, private sector, and global competitiveness for their employability.

Committee on Molecular Biology & Biotechnology

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes	Broad Subject Coordinator	Discipline Coordinator
Molecular Biology & Biotechnology	Molecular Biology & Biotechnology	M.Sc. (Agri. Molecular Biology and Biotechnology)	Dr. H. B. Patil ADP, VDCoAB, Latur, VNMKV., Parbhani	Dr. S. B. Sakhare Officer Incharge, Biotechnology Centre, Dr. PDKV., Akola
		Ph.D. (Agri. Molecular Biology and Biotechnology)		

Co-opted members for revision of M. Sc. courses

1. Dr. Vivek Chimote, Associate Professor, State Level Biotechnology Center, MPKV., Rahuri
2. Dr. A. Bharose, Associate Professor, Vilasrao Deshmukh College of Agril. Biotechnology, VNMKV, Latur
3. Dr. S. Sawardekar, Associate Professor, Biotechnology Centre, Dr. BSKKV, Dapoli
4. Dr. M. P. Moharil, Associate Professor, Biotechnology Centre, Dr. PDKV., Akola
5. Dr. P. V. Jadhav, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola
6. Dr. D. R. Rathod, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola
7. Dr. Deepika Padole, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola

Co-opted members for revision of Ph. D. courses

1. Dr.M. P. Moharil, Associate Professor, Biotechnology Centre, Dr. PDKV., Akola
2. Dr. P. V. Jadhav, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola
3. Dr. D. R. Rathod, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola
4. Dr. Deepika Padole, Assistant Professor, Biotechnology Centre, Dr. PDKV., Akola

Implementation of New Curriculum

The universities offering PG programmes in (Agri.) Molecular Biology & Biotechnology need to be supported for establishing specialized laboratories equipped with state-of-the art equipment's for conducting practical classes especially, genetic engineering, plant tissue culture, plant transformation, molecular breeding, and molecular biology.

One-time catch-up grant should be awarded to each SAU, offering PG programmes in (Agri.) Molecular Biology and Biotechnology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculties in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in different discipline of (Agri.) Molecular Biology and Biotechnology in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of (Agri.) Molecular Biology and Biotechnology throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Nomenclature of Degree Programme

(a) M.Sc. Programmes
M.Sc. (Agri.) in Molecular Biology and Biotechnology

(b) Ph. D. Programmes
Ph.D. (Agri.) in Molecular Biology and Biotechnology

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – To elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 500/600 series courses as well as research topics.
- Lecture schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

- **Master's Degree Programme**
  B.Sc.(Agri.)@/ B.Sc.(Hons.) Agriculture@/ B.Sc.(Hort.)@/B.Sc.(Hons.)Horticulture@/ B.Sc.(Forestry)@/ B.Sc.(Hons.)Forestry@/ B.Sc.(Agricultural Biotechnology) / B.Tech.(Biotechnology)/ B.Tech.(Agricultural Biotechnology)/ B.Tech. (Food Science)@/ B.Tech.(Food Tech./Food Technology)@/ B.F.Sc.@ or equivalent degree@ with four years duration of Agriculture-related Universities and having the Common Entrance Test in

Agricultural Biotechnology faculty conducted by the MAUEB, Pune or competent authority as applicable.

(Note:-@Students admitted with other than UG degree in Agricultural Biotechnology/ B. Tech. Biotechnology will have to complete the Deficiency Courses with 6-10 credits as prescribed by SAC.

Doctoral Degree Programme
Master's degree in concerned discipline with two years duration and minimum 6.5/10 or equivalent OGPA/ equivalent percentage of marks of Agriculture-related Universities and having the Common Entrance Test in Agriculture faculty conducted by MAUEB, Pune or competent authority as applicable

Course and Credit Requirements

Course Details	**Credits**	
	Master's Degree	**Doctoral Degree**
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

M.Sc. (Agri. Molecular Biology and Biotechnology)
Course Structure

LIST OF CORE COURSES/ MAJOR/ MINOR/SUPPORTING/COMPULSORY NON-CREDIT COURSES

M.Sc. (Agri.) Molecular Biology and Biotechnology

Course Code	Course Title	Credit Hrs.
Major: 20 credits (12 credits of core + 8 credits of optional)		
MBB 501	Principles of Biotechnology	3+0
MBB 502*	Fundamentals of Molecular Biology	3+0
MBB 503*	Molecular Cell Biology	3+0
MBB 504*	Techniques in Molecular Biology I	0+3
MBB 505*	Omics and Systems Biology	2+1
MBB 506	Plant Genetic Engineering	3+0
MBB 507	Techniques in Molecular Biology II	0+3
MBB 508	Introduction to Bioinformatics	2+1
MBB 509	Plant Tissue culture	2+1
MBB 510	Microbial and Industrial Biotechnology	2+1
MBB 511	Molecular Plant Breeding	2+1
MBB 512	IPR, Bio-safety and Bioethics	2+0
MBB 513	Immunology and Molecular Diagnostics	3+0
MBB 514	Nano Biotechnology	2+1
MBB 515	Environmental Biotechnology	3+0
MBB 516#	Bio-entrepreneurship	1+0
MBB 517#	Stress Biology and Genomics	2+0
MBB 518#	Gene Regulation	2+0

Minor (8 Credits)– from one of the related disciplines

Biochemistry
Genetics and Plant Breeding
Microbiology
Plant Physiology
Plant Pathology
Entomology
Bioinformatics
Plant Genetic Resources

Suggestive Minor Courses

GPB 502	Principles of Plant Breeding	2+1
GPB 506*	Molecular Breeding and Bioinformatics	2+1
ENT 507	Host Plant Resistance	1+1
ENT 519	Molecular Approaches in Entomology	2+1
PL PATH 509	Disease Resistance in Plants	2+0
PP 503*	Plant Developmental Biology: Physiological and Molecular Basis	2+1

PP 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1
PP 506	Physiological and Molecular Mechanisms of Mineral Nutrient Acquisition and their Functions	2+1

Basic Supporting (6 Credits) from the following disciplines

Biochemistry

Microbiology

Genetics and Plant Breeding

Statistics

Bioinformatics

Computer Applications

Suggestive Supporting Courses

BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2
STAT 511	Experimental Designs	2+1
STAT 501	General Statistical Methods and Computer Applications	2+1
STAT 512	Basic Sampling Techniques	2+1
MICRO 504	Microbial genetics	2+1
MICRO 508	Bacteriophages	1+1
BI 501	Introduction to Bioinformatics & Computational Biology	2+1
BI 503	Genome Assembly and Annotation	1+1
MCA 514	Statistical Computing	1+1
MCA 564	Bioinformatics Computing	1+1
Common Courses		
MBB 591	Masters Seminar	0+1
MBB 599	Masters Research	0+30
	Total	**70**

***Core Courses; # New Courses**

Common compulsory PGS courses: (Non-Credit)

Course code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

Compulsory Non-Credit Deficiency Courses
(Those who are non-Agricultural Biotechnology/ B. Tech. Biotechnology Graduates)

Course Code	Course Title	Credit Hrs.
MBB-411	Introduction to Biotechnology	2+1
MBB-412	Plant Tissue culture	2+1
MBB-413	Molecular Biology	2+1
MBB-414	Recombinant DNA Technology	2+1
MBB-415	General Biochemistry	3+1

Students other than UG degree in Agricultural Biotechnology/ B. Tech. Biotechnologywill be required to completed Non-credit deficiency courses (6 to 10 credits) from the above courses related to the discipline in which admitted and as decided by the Student Advisory committee.

Ph.D. (Agri.) Molecular Biology and Biotechnology
Course Structure

Ph. D. (Agri.) Molecular Biology and Biotechnology

Major: 12 credits (6 credits of core + 6 credits of optional)

Course Code	Semester	Course Title	Credit Hrs.
MBB 601*		Plant Molecular Biology	3+0
MBB 602*		Plant Genome Engineering	3+0
MBB 603		Plant Omics and Molecular Breeding	3+0
MBB 604		Commercial Plant Tissue Culture	2+0
MBB 605#		Plant Microbe interaction	2+0
MBB 606#		RNA Biology	1+0
MBB 607#		Plant Hormones and Signaling	2+0
MBB 608#		Computational and Statistical tools in Biotechnology	2+1

Minor (6 credits) from any of the following disciplines

Biochemistry
Genetics and Plant Breeding
Microbiology
Plant Physiology
Plant Pathology
Entomology
Bioinformatics
Plant Genetic Resources

Suggestive Minor Courses

BIOCHEM 603		Biochemistry of Biotic and Abiotic Stresses	3+0
BIOCHEM 605		Concepts and application of Omics inBiological Science	3+0
ENT 607		Plant Resistance to Insects	1+1
ENT 609		Molecular Entomology	1+1
PL PATH 604		Molecular Basis of Host-pathogen Interaction	2+1
GPB 603		Molecular Cytogenetics for Crop Improvement	2+0
MICRO 605		Plant microbe interactions	2+1
PP 601		Functional Genomics and Genes Associated with a Few Physiological Processes	2+0
PP 604		Plant Phenomics – Next Generation Phenomics Platforms	2+0

Supporting (5 credits) from the following disciplines

Biochemistry
Microbiology
Genetics and Plant Breeding
Statistics
Bioinformatics
Computer Applications

Suggestive Supporting Courses			
STAT 602		Simulation Techniques	1+1
STAT 612		Advanced Design of Experiments	2+1
BI 601		Genome wide association study	2+1
BI 605		Comparative and functional genomics	1+1
Common Courses			
MBB 691		Doctoral Seminar I	0+1
MBB 692		Doctoral Seminar II	0+1
MBB 699		Doctoral Research	0+75
Total			100

***Core Courses; # New Courses**

Course Contents
M.Sc. (Agri.)Molecular Biology & Biotechnology

MBB-501 Principles of Biotechnology 3+0

Objective

To understand the basics of Molecular biology, plant and microbial Biotechnology
Importance and applications in agriculture, case studies and success stories
Public education, perception, IPR and related issues

Theory

Unit I (12 Lectures)

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Unit II (16 Lectures)

Structure of DNA,RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III (8 Lectures)

Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.

Unit IV (12 Lectures)

Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers, and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Reading

Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. Molecular Biology ofthe Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York
Brown T A. 2010. Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
Primrose SB and Twyman R. 2006. Principles of gene Manipulation 7th edition, WileyBlackwell

Krebs,J.E.,Goldstein,E.S.,Kilpatrick,S.T.2017.*Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc

Teaching Schedule

Theory

Sr. No.	Topic	No. of Lecture(s)
1.	History, scope and importance of Biotechnology	01
2.	Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology	08
3.	Basics of Biotechnology	01
4.	Primary metabolic pathways, Enzymes and its activities	02
5.	Structure of DNA,RNA and protein, their physical and chemical properties	04
6.	DNA function: Expression, exchange of genetic material, mutation	04
7.	DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization	03
8.	DNA/RNA libraries; Applications of gene cloning in basic and applied research	02
9.	Plant transformation: Gene transfer methods and applications of GM crops	03
10.	Molecular analysis of nucleic acids -PCR and its application in agriculture and industry	01
11.	Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications	02
12.	DNA sequencing, different methods	02
13.	Plant cell and tissue culture techniques and their applications	01
14.	Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.	02
15.	Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions,	04
16	Success stories in Biotechnology, Careers and employment in biotechnology	02
17	Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology	06
	Total	**48**

MBB-502 Fundamentals of Molecular Biology 3+0

Objective

To understand the basics of DNA, RNA, structure, types and chromatin assembly.
To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.
To understand different levels of gene regulation and the pathways involved.

Theory

Unit I (8 Lectures)

Historical developments of molecular biology, Nucleic acids as genetic material,Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure;secondary structure, Forms of DNA: A,B, Z and their function; Structure andTypesof RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNAre-association kinetics, Types of repeat sequences.

Unit II (10 Lectures)

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Unit III (8 Lectures)

Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors, Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.

Unit IV (10 Lectures)

Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, trans-peptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability - Protein turnover and degradation.

Unit V (12 Lectures)

Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: *lac* and *trp* operons, attenuation, anti-termination, stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix turn-helix, helix-loop-helix etc. Epigenetic regulations

Suggested Reading

Nelson DL and Cox M.M. 2017. Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York.

Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc.

Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York.

Alberts, B. 2017. Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.

Allison, L.A. 2011. Fundamentals of Molecular Biology. 2nd Edition, John Wiley and Sons.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Historical developments of molecular biology,	01
2.	Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids, Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function	03
3.	Structure and Types of RNA Genome organization in prokaryotes and eukaryotes	02
4.	DNA Topology; DNA re-association kinetics, Types of repeat sequences	02
5.	Central dogma of Molecular Biology; DNA replication- Classical experiments	02
6.	Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms	04
7.	Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms,	02
8.	Recombination: Homologous and non-homologous, Genetic consequences	02
9.	Prokaryotic transcription, initiation, elongation and termination, promoters,	02
10.	Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination,	02
11.	Eukaryotic promoters and enhancers, Transcription factors, Post transcriptional processing,	02
12.	Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.	02

13.	Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis;	02
14.	Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, trans-peptidation and termination of translation	05
15.	Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.	03
16	Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators Operon concept: *lac* and *trp* operons, attenuation, anti-termination, stringent control	05
17	Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation	04
18	Families of DNA binding transcription factors: Helix turn-helix, helix-loop-helix etc. Epigenetic regulations	03
	Total	**48**

MBB-503 Molecular Cell Biology 3+0

Objective

To understand the basic structure and function of plant and animal cell

To get insights in to the basic cellular processes, transport, signaling, cell movement, cell division and general regulation mechanisms.

Theory

Unit I (8 Lectures)

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory,treeof life, General structure and differences between prokaryotic and eukaryoticcell; Similarities and distinction between plant and animal cells; different kinds ofcells inplant and animal tissues.

Unit II (8 Lectures)

Cell wall, cell membrane, structure and composition of bio-membranes, Structureand function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus,Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles,Nucleus, Cyto-skeletal elements.

Unit III (12 Lectures)

Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanismof protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors, signaling through G-protein coupledreceptors, enzyme linked receptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

Unit IV (10 Lectures)

Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular event sat M phase, mitosis and cytokinesis, Ribosomes in relation to cell growth and division, Extracellular and intracellular Control of Cell Division; abnormal cell division: cancer- hall marks of cancer and role of onco genes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

Unit V (10 Lectures)

Morphogenetic movements and the shaping of the body plan, Cell diversification, cell memory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (C. elegans; Drosophila); Plant development.

Suggested Reading

Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.

Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin,K.C., 2016. *Molecular Cell Biology* 8th Edition. W.H. Freeman & Co. New York.

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P.,2013 *Essential of Cell Biology*, WW Norton & Co, Inc.

Cooper, G.M. and Hausman, R.E. 2013. *The cell: A Molecular Approach* 6th edition, Sinauer Associates, Inc.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, tree of life,	03
2.	General structure and differences between prokaryotic and eukaryotic cell	02
3.	Similarities and distinction between plant and animal cells; different kinds of cells in plant and animal tissues	03
4.	Cell wall, cell membrane, structure and composition of bio-membranes	02
5.	Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements	06
6.	Membrane transport; Diffusion, osmosis, ion channels, active transport	02
7.	Mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis	04
8.	General principles of cell communication: hormones and their receptors, signaling through G-protein coupled receptors, enzyme linked receptors	03
9.	Signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix	03
10.	Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular event sat M phase, mitosis and cytokinesis	04
11.	Ribosomes in relation to cell growth and division, Extracellular and intracellular	02
12.	Control of Cell Division; abnormal cell division: cancer- hall marks of cancer and role of onco genes and tumor suppressor genes in cancer development	04
13.	Programmed cell death (Apoptosis)	01
14.	Morphogenetic movements and the shaping of the body plan, Cell diversification, cell memory, cell determination, and the concept of positional values	04
15.	Differentiated cells and the maintenance of tissues and organ development	02
16	Stem cells: types and applications; Basics of Animal development in model organisms (C. elegans; Drosophila)	03
17	Plant development	01
	Total	**48**

MBB-504 Techniques in Molecular Biology I 0+3

Objective

To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology

To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics

Practical's

1. Good lab practices, preparation of buffers and reagents.
2. Principle of centrifugation and spectrophotometry.
3. Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.
4. Isolation of plasmid DNA from bacteria.
5. Growth of lambda phage and isolation of phage DNA.
6. Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Marigold).
7. Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
8. PCR using isolated DNA.
9. PAGE Gel electrophoresis.
10. Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.
11. Transformation of *E. coli* and selection of transformants
12. Chromatographic techniques
    i. TLC
    ii. Gel Filtration Chromatography,
    iii. Ion exchange Chromatography,
    iv. Affinity Chromatography
13. Dot blot analysis, Southern hybridization, Northern hybridization.
14. Western blotting and ELISA.
15. Radiation safety and non-radio isotopic procedure.

Suggested Reading

Sambrook, J., and Russell, R.W. 2001. *Molecular Cloning: A Laboratory Manual* 3rd Edition,
Cold spring harbor laboratory press, New York.
Wilson, K., and Walker, J., 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th edition, Cambridge University Press.
Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. *Short Protocols in Molecular Biology* 5th edition, Current Protocols publication.

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Good lab practices, preparation of buffers and reagents.	01
2.	Principle of centrifugation and spectrophotometry	01
3.	Growth of bacterial culture and preparation of growth curve,	01
4.	Isolation of Genomic DNA from bacteria	01
5.	Isolation of plasmid DNA from bacteria.	01
6.	Growth of lambda phage and isolation of phage DNA.	01
7.	Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Marigold). Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry	04
8.	PCR using isolated DNA.	01
9.	PAGE Gel electrophoresis.	01
10.	Restriction digestion of plasmid and phage DNA, ligation,	01
11.	Recombinant DNA construction.	04
12.	Transformation of *E. coli* and selection of transformants	03
13.	Chromatographic techniques	05
14.	Dot blot analysis, Southern hybridization, Northern hybridization.	04
15.	Western blotting and ELISA.	01
16	Radiation safety and non-radio isotopic procedure	01
	Total	**31**

MBB-505 Omics and Systems Biology 2+1

Objective

To get a basic overview of genomics, proteomics, ionomics and metabolomics

Togetaprimaryinformationontheapplicationofomicsscienceacrosstheindustry

Theory

Unit I (8 Lectures)

Forward and Reverse Genetics, structural and functional genomics, principles of various sequencing methods; Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, map based cloning, basics of ionomics analysis, different method

Unit II (6 Lectures)

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Edman degradation peptide sequencing, Peptide fingerprinting, Gel based (2D PAGE) and gel free (HPLC/MS), Basics of software used in proteomics, MASCOT,PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based eXpression system and purification

Unit III (6 Lectures)

Metabolomics and its applications, Metabolite extraction-High throughput Analysis and interpretation, chromatography (HPLC/GC/LC),UV-Visible Spectroscopy; Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome. High Throughput phenotyping with Sensors.

Unit IV (6Lectures)

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Biological oscillators, Genetic oscillators, Quorum Sensing, Cell-cell communication, Drosophila Development, Pathways to Network, Gene regulation at a single cell level, transcription network, REGULATORY CIRCUITS, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis

Practical (12)

1. Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.
2. BSA Standard curve preparation, Extraction of protein and estimation methods.
3. Quantification of proteins from different plant tissues using spectrophotometry.
4. 2-D Gel Electrophoresis, 2-D Image analysis.
5. Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system).

6. Demonstration on MALDI-TOF.
7. Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

Suggested Reading

Primrose, S. B. and Twyman, R. 2006. Principles of Gene Manipulation 7th edition, Wiley Blackwell

Wilson, K., and Walker, J. 2018. Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Forward and Reverse Genetics, structural and functional genomics, principles of various sequencing methods	02
2.	Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps,	03
3.	Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes	03
4.	preliminary genome data analysis, map based cloning, basics of ionomics analysis, different methods	02
5.	Protein-basics: primary-, secondary- and tertiary structure	01
6.	Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry	01
7.	Proteomics: Edman degradation peptide sequencing, Peptide fingerprinting, Gel based (2D PAGE) and gel free (HPLC/MS)	02
8.	Basics of software used in proteomics, MASCOT,PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based expression system and purification	02
9.	Metabolomics and its applications, Metabolite extraction-High throughput Analysis and interpretation, chromatography (HPLC/GC/LC),UV-Visible Spectroscopy	02
10.	Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA)	02
11.	Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome. High Throughput phenotyping with Sensors	02
12.	Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Biological oscillators, Genetic oscillators, Quorum Sensing	02
13.	Cell-cell communication, Drosophila Development, Pathways to Network, Gene regulation at a single cell level, transcription network, Regulatory Circuits	02

14.	Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis	02
	Total	**26**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis	02
2.	BSA Standard curve preparation, Extraction of protein and estimation methods	01
3.	Quantification of proteins from different plant tissues using spectrophotometry.	01
4.	2-D Gel Electrophoresis, 2-D Image analysis	02
5.	Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system)	02
6.	Demonstration on MALDI-TOF.	02
7.	Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods	02
	Total	**12**

MBB-506	Plant Genetic Engineering	3+0

Objective

To get a basic overview of molecular cloning, vectors and genomic library construction.

To get an overview of PCR and its applications, sequencing, gene knockouts, transgenics etc.

Theory

Unit I (10 Lectures)

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4DNA polymerase, Polynucleotide kinase etc, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in-situ* hybridization; Chromatin Immuno-precipitation; DNA-Protein Interactions: Electro mobility shift assay. ssDNA Endonuclease for TILLING

Unit II (14 Lectures)

Plasmids; Bacterio phages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; recombinant protein; Expression vectors; pMal and pET-based vectors; Recombinant Protein purification; His-tag; (Polyhistidine)GST-tag (glutathione S-transferase); MBP-tag (maltose-binding protein), etc.; Baculo virus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; Cdna and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologouse expression. Introduction of DNA into mammalian cells; Transfection techniques

Unit III (12 Lectures)

Principles of PCR, Primer design, DNA polymerases, Types of PCR–multiplex, nested, reverse transcriptase, real-time PCR, touch-down PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

Unit IV (12 Lectures)

Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants–molecular and Biochemical assays and genetic analysis - Identification of gene integration site ds-RNA directed gene silencing, co-suppression,- Advancemethods–*cis*genesis,intragenesisandtargetedgenome modification, Gene editing –ZFN, TALENS and CRISPR. Transient gene expression (VIGS/ Agrobacterium infiltration/ Gene Gun/ Morpholino oligos), Application of transgenic technology.

Suggested Reading

Brown, T.A. 2010. Gene Cloning and DNA Analysis an Introduction. 6th edition, Wiley Blackwel.

Primrose, S.B. and Twyman, R.2006 .Principles of Gene Manipulation 7th edition, Wiley Blackwell.

Sambrook,J. ,and Russell,R.W.2001. Molecular cloning: A laboratory manual 3rd Edition, Cold springharbour laboratory press, New York.

Wilson,K. ,and Walker,J. 2018. Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Historical background	01
2.	Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinase etc, Cohesive and blunt end ligation	02
3.	Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes	02
4.	Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in-situ* hybridization	03
5	Chromatin Immuno-precipitation; DNA-Protein Interactions: Electromobility shift assay. ssDNA Endonuclease for TILLING	02
6.	Plasmids; Bacterio phages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors	02
7.	Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; recombinant protein	02
8.	Expression vectors; pMal and pET-based vectors; Recombinant Protein purification; His-tag; (Polyhistidine)GST-tag (glutathione S-transferase); MBP-tag (maltose-binding protein), etc.; Baculo virus vectors system	03
9.	Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; Cdna and genomic libraries	02
10.	cDNA and genomic cloning, Jumping and hopping libraries, Protein protein interactive cloning and Yeast two hybrid system; Phage display	03
11.	Principles in maximizing gene expression; Codon optimization for heterologouse expression. Introduction of DNA into mammalian cells; Transfection techniques	02
12.	Principles of PCR, Primer design, DNA polymerases	02
13.	Types of PCR–multiplex, nested, reverse transcriptase, real-time PCR, touch-down PCR, hot start PCR, colony PCR, cloning of PCR products	04
14.	T-vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics	03

15.	Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay	03
16.	Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment.	02
17.	Vectors and transgene design Promoters and Marker genes.	01
18.	Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants–molecular and Biochemical assays and genetic analysis	03
19.	Identification of gene integration site ds-RNA directed gene silencing, co-suppression,- Advance methods–*cis* genesis, intragenesis and targeted genome modification,	03
20.	Gene editing –ZFN, TALENS and CRISPR. Transient gene expression (VIGS/ Agrobacterium infiltration/ Gene Gun/ Morpholino oligos), Application of transgenic technology.	03
	Total	**48**

MBB-507 Techniques in Molecular Biology II 0+3

Objective

To get a basic overview of molecular biology techniques, good lab practices and molecular markers.
To get a hands on training in RNAi, microarrays, yeast 2 hybrid and immunological techniques.

Practical's

1. Construction of gene libraries (c-DNA and Genomics).
2. Synthesis and cloning of c-DNA.
3. Real time PCR and interpretation of data.
4. Molecular markers
   i. RAPD.
   ii. SSR.
   iii. AFLP/ISSR and their analysis.
5. Case study of SSR markers-construction of linkage map.
6. QTL analysis using genotypic data based on SSR.
7. SNP identification and analysis.
8. Micro array studies and use of relevant software.
9. Proteomics
   i. 2Dgels,
   ii. Mass spectrometry
10. RNAi- designing of construct, phenotyping of the plant.
11. Yeast1and2-hybridinteraction.
12. Generation and screening of mutants.
13. Transposon mediated mutagenesis.
14. Immunology and molecular diagnostics: Ouchterlony double diffusion, Immuno precipitation, Radiation Immuno diffusion, Immuno electrophoretic, Rocket Immuno electrophoretic, Counter Current Immuno electrophoretic, ELISA, Latex Agglutination, Immuno histochemistry.

Suggested Reading

Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and MolecularBiology*8th Edition, Cambridge University Press

Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M.2004. *Short Protocols in Cell Biology*. John Wiley & Sons, New Jersey

Hawes,C.,and Satiat-Jeunemaitre, B.2001. *Plant Cell Biology: Practical Approach*. Oxford University Press, Oxford

Sawhney,S.K.,Singh,R.2014.*Introductory Practical Biochemistry*, Alpha science international limited.

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Construction of gene libraries (c-DNA and Genomics).	02
2.	Synthesis and cloning of c-DNA.	03
3.	Real time PCR and interpretation of data.	02
4.	Molecular markers i. RAPD. ii. SSR. iii. AFLP/ISSR and their analysis.	05
5.	Case study of SSR markers-construction of linkage map.	01
6.	QTL analysis using genotypic data based on SSR.	01
7.	SNP identification and analysis.	01
8	Micro array studies and use of relevant software.	01
9	Proteomics i. 2Dgels, ii. Mass spectrometry	05
10	RNAi- designing of construct, phenotyping of the plant.	03
11	Yeast1and 2-hybrid interaction	03
12	Generation and screening of mutants.	01
13	Transposon mediated mutagenesis.	01
14	Immunology and molecular diagnostics: Ouchterlony double diffusion, Immuno precipitation	03
15	Immunology and molecular diagnostics: Radiation Immuno diffusion, Immuno electrophoretic, Rocket Immuno electrophoretic	03
16	Immunology and molecular diagnostics: Counter Current Immuno electrophoretic, ELISA, Latex Agglutination, Immuno histochemistry	03
	Total	**38**

MBB-508 Introduction to Bioinformatics 2+1

Objective

To get a basic overview of computational techniques related to DNA, RNA and protein analysis.

To get a hands-on training in software's and programs used to analyse, assemble or annotate genomes, phylogenetics, proteomics etc

Theory

Unit I (8Lectures)

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, Gene Bank, DDBJ, secondary database, structural databases–PDB, SCOP and CATH, Specialized genomic resources, Microarray database.

Unit II (10Lectures)

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequenceanalysis, Sequence submission and retrieval system- SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment-BLAST and its variants; Phylogenetic analysis- CLUSTALX, CLUSTALW, Phylip, Tcoffee

Unit III (10Lectures)

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3D Structure Prediction: Evaluation of models-Structure validation and refinement-Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing- principles and methods. Drug discovery**,** Structure Based Drug Design-Rationale for computer aided drug designing, basic principles, docking, QSAR.

Practical (12)

1. Usage of NCBI resources
2. Retrieval of sequence/ structure from databases and submission
3. Different Databases, BLAST exercises.
4. Assembly of DNA and RNASeq data
5. Annotation of assembled sequences, Phylogenetics and alignment
6. Visualization of structures, Docking of ligand receptors
7. Protein structure analysis and modeling

Suggested Reading

Attwood, T.K., and Parry Smith, D.J. 2004. *Introduction to Bioinformatics*, Pearson Education (Singapore) Pvt. Ltd.

David Edwards (Ed.) 2007. *Plant Bioinformatics: Methods and Protocols*. Humana Press, New Jersey, USA. Cold Spring Harbor Laboratory Press, U.S.

Pevsner J.2009. *Bioinformatics and Functional Genomics*, 2nd edition, Wiley-Blackwell.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Bioinformatics basics, scope and importance of bioinformatics	02
2.	Biological databases for DNA and Protein sequences -PIR, SWISSPROT, Gene Bank, DDBJ, secondary database, structural databases–PDB, SCOP and CATH,	04
3.	Specialized genomic resources, Microarray database	02
4.	Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes	02
5.	Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin,	02
6.	Sequence alignment, pair wise alignment techniques, multiple sequence alignment;	02
7.	Tools for Sequence alignment-BLAST and its variants;	02
8.	Phylogenetic analysis- CLUSTALX, CLUSTALW, Phylip, Tcoffee	02
9.	Sequencing of protein; Protein secondary structure prediction-Chousfasman, GOR Method	02
10.	Protein 3D Structure Prediction: Evaluation of models-Structure validation and refinement-Ramachandran plot	02
11.	Force field calculations, SAVES. Protein function prediction-sequence and domain based	02
12.	Primer designing- principles and methods. Drug discovery**,** Structure Based Drug Design-Rationale for computer aided drug designing, basic principles,	02
13.	Docking, QSAR	02
	Total	**28**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Usage of NCBI resources	01
2.	Retrieval of sequence / structure from data bases and submission	01
3.	Different Databases, BLAST exercises.	01
4.	Assembly of DNA and RNA Seq data	01
5.	Annotation of assembled sequences, Phylogenetics and alignment	01
6.	Visualization of structures, Docking of ligand receptors	02
7.	Protein structure analysis and modeling	02
	Total	**09**

MBB-509 Plant Tissue Culture 2+1

Objective

To provide insight into principles of plant cell culture and genetic transformation.

To get a hands- on training in basic plant tissue culture techniques, callusing, micro-propagation and analysis.

Theory

Unit I (12Lectures)

History of plant tissue culture, principle of Totipotency; Nutritional requirements of in vitro cultures & Tissue culture media; Planthormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; Test tube fertilization; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods–PCR, ELISA

Unit II (12Lectures)

Micro propagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis-production of androgenic and gynogenic haploids-diploidization; Protoplast culture-isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization-Production of Somatic hybrids and Cybrids; Wide hybridization-embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

Unit III (12Lectures)

Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites-techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance; Artificial seeds, In vitro germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

Practical(12)

1. Preparation of stocks - macronutrients, micronutrients, vitamins and hormones,filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoogmedium.
2. Micro-propagation of plants by nodal and shoot tipculture.
3. Embryo culture to overcome in compatibility, Anther culture for haploid production.
4. Callus induction in tobacco leaf discs / / Plants of local importance, regeneration of shoots, root induction, role of hormones in morphogenesis.
5. Acclimatization of tissue culture plants and establishment in greenhouse.
6. Virus indexing in tissue culture plants. (Using PCR and ELISA).
7. Plan of a commercial tissue culture unit.

Suggested Reading

Razdan, M.K. 2003. *Introduction to plant tissue culture*, 2nd edition, Oxford publications group

Butenko, R.G. 2000. *Plant Cell Culture* University Press of Pacific

Herman, E.B. 2008. *Media and Techniques for Growth, Regeneration and Storage,*

Agritech Publications, New York, USA.

Bhojwani, S. S and Dantu P. 2013. *Plant Tissue Culture–An Introductory Text*. Springer Publications.

Gamborg, O.L and G.C. Philips (eds.). 2013. *Plant Cell, Tissue and Organ culture-Lab Manual*. Springer Science & Businessmedia

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	History of plant tissue culture, principle of Totipotency; Nutritional requirements of in vitro cultures & Tissue culture media	03
2.	Planthormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; Test tube fertilization	05
3.	National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods–PCR,ELISA	04
4.	Micro propagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micro grafting	03
5.	Androgenesis and gynogenesis-production of androgenic and gynogenic haploids-diploidization	03
6.	Protoplast culture-isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization-Production of Somatic hybrids and Cybrids	03
7.	Wide hybridization-embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture	03
8.	Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production	03
9.	Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance	03
10.	Artificial seeds, In vitro germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories	03
11.	Market assessment; project planning and preparation, economics, government policies	03
	Total	**36**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.	02
2.	Micro-propagation of plants by nodal and shoot tip culture.	03
3.	Embryo culture to overcome incompatibility, Anther culture for haploid production	03
4.	Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.	03
5.	Acclimatization of tissue culture plants and establishment in green house.	02
6.	Virus indexing in tissue culture plants. (Using PCR and ELISA).	02
7.	Plan of a commercial tissue culture unit	02
	Total	17

MBB-510 Microbial / Industrial Biotechnology 2+1

Objective

To familiarize about the various microbial processes / systems / activities, which have been used for the development of industrially important products / processes.

Theory

Unit I (8Lectures)

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

Unit II (8Lectures)

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

Unit III (8Lectures)

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bio-augmentation with production of vitamin case study; Bioreactors, their design and types; Immobilized enzymes- based bioreactors; Bioreactor design: downstream processing and production recovery (Chromatographic techniques, ultra filtration, micro filtration, fermentation economics); Micro encapsulation technologies for immobilization of microbial enzymes.

Unit IV (8Lectures)

Environmental Biotechnology, bio-treatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio-remediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

Practical

1. Isolation of industrially important microorganisms, their maintenance and improvement.
2. Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.
3. Study of bio-reactors and their operations.
4. Production of bio-fertilizers.
5. Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products.
6. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation.
7. Determination of mass transfer coefficient

Suggested Reading

Waites,M.J.,Morgan,N.L.,Rockey,J.S.,Higton,G.2001. Industrial Microbiology: An Introduction, Wiley-Blackwell.

Slater,A., Scott, N.W., & Fowler, M.R.2003. The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.

Kun, L.Y. (Ed.). 2003.Microbial biotechnology: principles and applications. World Scientific Publishing Company.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Introduction, scope and historical developments;	02
2.	Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms	02
3.	Primary metabolites, production of industrial ethanol as a case study	01
4.	Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study;	02
5.	Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities;	03
6.	Metabolic pathway engineering of microbes for production of novel product for industry	02
7.	Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries	02
8.	Bio-transformations, Bio-augmentation with production of vitamin case study;	02
9.	Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Bioreactor design: downstream processing and production recovery (Chromatographic techniques, ultra-filtration, micro filtration, fermentation economics)	02
10	Micro encapsulation technologies for immobilization of microbial enzymes	02
11	Environmental Biotechnology, bio-treatment for pollution control, treatment of industrial and other wastes	03
12	Biomass production involving single cell protein; Bio-remediation of soil	02
	Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc	03
	Total	**30**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Isolation of industrially important microorganisms, their maintenance and improvement.	01

2.	Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.	03
3.	Study of bio-reactors and their operations.	02
4.	Production of bio-fertilizers.	01
5.	Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products.	03
6.	Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation.	02
7.	Determination of mass transfer coefficient	01
	Total	**13**

MBB-511 Molecular Plant Breeding 2+1

Objective

To familiarize the students about the use of molecular biology tools in plant breeding.

To provide a hands-on training in data analysis, diversity analysis and mapping of genes and QTLs.

Theory

Unit I (8 Lectures)

Inheritance of qualitative and quantitative traits. Heritability – its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency. Development of different kinds of segregating populations – F2, F3, BC1F1, BC1F2, BC4F2, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).

Unit II (8 Lectures)

Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPs, InDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, F2, F3, BC1F1, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.

Unit III (8 Lectures)

QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS),Principle of Association mapping–GWAS-SNP genotyping methods, DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq- Nano pore sequencing, Principles and methods of Genomic Selection, Fine mapping of genes/QTL; Development of gene-based markers; Allele mining by TILLING and Eco-TILLING.

Unit IV (8 Lectures)

Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and

DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

Practical

1. Construction of linkage map.
2. QTL analysis using the QTL cartographer and other software.
3. SNP data analysis using TASEEL.
4. Detection of haplotype block using SNP data-pLink software.
5. Genotyping by sequencing methods–Illumina genotyping platform.
6. Marker assisted breeding–MABB case studies quality traits in rice/soybean/ maize.
7. Genome Assisted Breeding in model crops, Genomic Selection models using themorphological and SNPdata

Suggested Reading

Acquaah, G.2007. *Principles of Plant Genetics and Breeding*, Blackwell Publishing Ltd. USA.

Weising, K., Nybom,H., Wolff, K.,and Kahl,G.2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*, 2nd ed. Taylor and Francis Group, Boca Raton, FL. Halford, N.2006. *Plant Biotechnology-Current and future applications of genetically modified crops*, John Wiley and Sons, England.

Singh,B.D. and Singh,A.K. 2015.*Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.

Boopathi,N. M.2013. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits* .Springer India.p293.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Inheritance of qualitative and quantitative traits. Heritability – its estimation	02
2.	Population structure of self- and cross-pollinated species, Factors affecting selection efficiency.	01
3.	Development of different kinds of segregating populations – F2, F3, BC1F1, BC1F2, BC4F2, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines)	03

4.	NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population)	02
5.	Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPs, InDel and DART seq;	04
6.	Inheritance of markers, Linkage analysis using test cross, F2, F3, BC1F1, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays	04
7.	QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS)	02
8.	Principle of Association mapping– GWAS-SNP genotyping methods, DART array sequencing, Illumina's Golden Gate Technology	02
9.	Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq- Nano pore sequencing	02
10	Principles and methods of Genomic Selection, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING	02
11	Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS)	02
12	Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples	02
13	Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection,	02
14	IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing	02
	Total	**32**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Construction of linkage map	01
2.	QTL analysis using the QTL cartographer and other software.	01
3.	SNP data analysis using TASEEL.	01
4.	Detection of haplotype block using SNP data-p Link software.	01

5.	Genotyping by sequencing methods–Illumina genotyping platform.	03
6.	Marker assisted breeding–MABB case studies quality traits in rice/maize.	03
7.	Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data	04
	Total	**14**

MBB-512 IPR, Biosafety and Bioethics 2+0

Objective

To familiarize the students about ethical and biosafety issues in plant biotechnology.

To provide a hands-on training in data analysis, diversity analysis and mapping of genes and QTLs.

Theory

Unit I (10 Lectures)

IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP; Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.

Unit II (8 Lectures)

Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of biohazards; Approved regulatory laboratory practice and principles, The Cartagena Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries

Unit III (8 Lectures)

Potential concerns of transgenic plants – Environmental safety and food and feed safety. Principles of safety assessment of Transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment – toxicity and allergenicity. Monitoring strategies and methods for detecting transgenics.

Unit IV (6 Lectures)

Field trails – Biosafety research trials – standard operating procedures, labeling of GM food and crop, Bio-ethics- Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy

Suggested Reading

Goel, D. and Parashar, S. 2013. IPR, biosafety, and bioethics.

Joshi, R. 2006. Biosafety and Bioethics.

Nambisan, P. 2017. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	IPR: historical background in India; trade secret; patent, trademark, design& licensing	02
2.	procedure for patent application in India; Patent Cooperation Treaty (PCT)	02
3.	Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP	02
4.	Implications of IPR on the commercialization of biotechnology products, ecological implications	02
5.	Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms	02
6.	Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety	02
7.	Biosafety and risk assessment issues; handling and disposal of biohazards; Approved regulatory laboratory practice and principles,	02
8.	The Cartagena Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy and Law;	02
9.	Regulations and Guidelines related to Biosafety in other countries	02
	Potential concerns of transgenic plants – Environmental safety and food and feed safety	02
10	Principles of safety assessment of Transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence	02
11	Risk Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms	02
12	Food and feed safety assessment – toxicity and allergenicity Monitoring strategies and methods for detecting transgenics	02
13	Field trails – Biosafety research trials – standard operating procedures	02
14	labeling of GM food and crop, Bio-ethics- Mankind and religion, social, spiritual & environmental ethics;	02
15	Ethics in Biotechnology, labeling of GM food and crop; Biopiracy	02
	Total	**32**

MBB-513 Immunology and Molecular Diagnostics 3+0

Theory

Unit I (6 Lectures)

Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs Descriptions of Antigens - immunogens, hapten and adjuvants.

Unit II (12 Lectures)

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin super family; Principles of cell signaling; Basis of self and non self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell mediated immune responses, ADCC; Cluster of Differentiations (CDs), Cytokines properties, receptors and therapeutic uses.

Unit III (8 Lectures)

Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system

Unit IV (10 Lectures)

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, immune fluorescence, flow cytometry and immune electron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques- lympho proliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs

Unit V (12 Lectures)

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection, Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens.

Suggested Reading

Owen J.A., Punt, J., &Stranford, S. A. 2013. Kuby immunology (p. 692). New York: WH Freeman.

Kenneth, M., and Weaver, C. 2017. Janeways Immunobiology, 9th Edition, New York, USA:Garland Science, Taylor & Francis publisher.

William, P. 2013. Fundamental of Immunology, 7th edition, Lippencott, William and Wilkins publisher.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Immunity and its classification; Components of innate and acquired immunity; Lymphatic system	02
2.	Hematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs	02
3.	Descriptions of Antigens - immunogens, hapten and adjuvants	02
4.	Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants	02
5.	Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin super family; Principles of cell signaling; Basis of self and non self discrimination	03
6.	Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity;	02
7.	T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell mediated immune responses,	03
8.	ADCC; Cluster of Differentiations (CDs), Cytokines properties, receptors and therapeutic uses	02
9.	Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility	02
10	Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing	02
11	Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens	02
12	Cell-cell co-operation, Hapten-carrier system	02
13	Precipitation, agglutination and complement mediated immune reactions;	01
14	Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, immune-fluorescence, flow cytometry and immune-electron microscopy	03
15	Surface plasmon resonance, Biosenor assays for assessing ligand – receptor interaction	02
16	CMI techniques- lympho proliferation assay, Mixed lymphocyte	02

	reaction, Cell Cytotoxicity assays	
17	Apoptosis, Transgenic mice, Gene knock outs	02
18	Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants	03
19	Recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies	03
20	Immunity to Infection, Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity	03
21	Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens	03
	Total	**48**

MBB-514 Nano Biotechnology 2+1

Objectives

Understanding the molecular techniques involved in structure and functions of nano biomolecules in cells such as DNA, RNA and proteins.

Theory

Unit I (8 Lectures)

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures – Bottoms up and Top-down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures) – Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, viz. electron microscopy, atomic force microscopy, etc).

Unit (8 Lectures)

Cell structure – Bio macromolecules: Types, Structure, Dynamics and interaction with water – Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, etc).

Unit III (8 Lectures)

Chemical, physical and biological properties of biomaterials and bio response: bio-mineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems

Unit IV (8 Lectures)

Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

Practical

1. Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials
2. Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles
3. Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputtering technique
4. Preparation ofthiolate silver nanoparticles, Purification and measurement of carbon nano materials
5. Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle
6. Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method
7. Synthesis of Zinc Oxide nanoparticle

Suggested Reading

Nalwa, H.S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publications.

Niemeyer C.M. and Mirkin C.A. (Eds) 2005. Nanobiotechnology: Concepts Applications and Perspectives, Wiley Inter-science publications.

Cao, G., and Wang, Y. 2004. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures	02
2.	Bottoms up and Top-down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures)	03
3.	Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, viz. electron microscopy, atomic force microscopy, etc)	03
4.	Cell structure – Bio macromolecules: Types, Structure, Dynamics and interaction with water	02
5.	Cellular nano machines – cellular transducers, membrane channels, membrane transporters	03
6.	Membrane motors – Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, etc)	03
7.	Chemical, physical and biological properties of biomaterials and bio response: bio-mineralization, biosynthesis	02
8.	Properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins)	03
9.	Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems	03
10	Nano-particular carrier systems	02
11	Micro- and Nano-fluidics, Drug and gene delivery system	02
12	Microfabrication, Biosensors, Chip technologies, Nano- imaging	02
13	Metabolic engineering and Gene therapy	02
	Total	**32**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials	02
2.	Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles	03
3.	Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputtering technique	02
4.	Preparation of thiolate silver nanoparticles, Purification and measurement of carbon nonmaterial	02
5.	Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticles	02
6.	Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method	02
7.	Synthesis of Zinc Oxide nanoparticles	02
	Total	**15**

MBB-515 Environmental Biotechnology 3+0

Objectives

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

Theory

Unit I (8 Lectures)

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; wastewater treatment - physical, chemical and biological processes; need for water and natural resource management.

Unit II (8 Lectures)

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals, detergents etc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filtration, etc.

Unit III (8 Lectures)

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture etc

Unit IV (8 Lectures)

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

Suggested Reading

Evans, G. M. and Furlong, J. C. 2010. Environmental Biotechnology: Theory and Application. 2nd edition, Wiley-Blackwell.

Jordening HJ and Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Basic concepts and environmental issues; types of environmental pollution	02
2.	Methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes	04
3.	Problems arising from high-input agriculture; need for water and natural resource management.	02
4.	Microbiology and use of micro-organisms in waste treatment; biodegradation	02
5.	Degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals, detergentsetc	03
6.	aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filtration, etc.	03
7.	Renewable and non-Renewable resources of energy; energy from solid waste	02
8.	Conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol	03
9.	Gasohol; biodegradation of lignin and cellulose; bio-pesticides; bio-fertilizers; composting; vermiculture etc	03
10	Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching	03
11	Enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain	03
12	Biodiversity and its conservation; biotechnological approaches for the management environmental problems.	02
	Total	**32**

MBB-516 Bio-entrepreneurship 1+0

Objectives

The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme

Theory

Unit I (4 Lectures)

Scope in biotechnology; types of bio-industries – biopharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bio-entrepreneurship – biotechnology in a global scale; –skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship-entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)

Unit II (4 Lectures)

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from various agencies; statutory and legal requirements for starting a company/venture.

Unit III (4 Lectures)

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

Unit IV (4 Lectures)

Knowledge centers e.g., in universities, innovation centers, research institutions (public & private) and business incubators; R&D for technology development and up gradation; assessment of technology development; managing technology transfer

Suggested Reading

Adams, D.J. and Sparrow, J.C. 2008. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.

Shimasaki, C.D. 2014. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.

Onetti, A., and Zucchella, A. 2014. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.

Jordan, J. F. 2014. Innovation, Commercialization, and Start-Ups in Life Sciences. London:

CRC Press.

Desai, V. 2009. The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Scope in biotechnology; types of bio-industries – biopharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bio-entrepreneurship – biotechnology in a global scale	02
2.	Skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship- entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)	02
3.	Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis;	01
4.	Funds/support from various agencies; statutory and legal requirements for starting a company/venture	03
5.	Entry and exit strategy; identifying needs of customers; Market linkages, branding issues	02
6.	Developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for ‘virtual startup company’. Pricing strategy	02
7.	Knowledge centers e.g., in universities, innovation centers, research institutions (public & private) and business incubators	02
8.	R&D for technology development and up gradation; assessment of technology development; managing technology transfer	02
	Total	**24**

MBB-517 Stress Biology and Genomics 2+0

Objectives

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance.

Theory

Unit I (10 Lectures)

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Unit II (12 Lectures)

Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging, tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation –plastid development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channeling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, biotech Strategies to overcome heavy metal stress Nutrient stress effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Unit III (10 Lectures)

Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.

Suggested Reading

Buchanan, B.B., Gruissem, W. and Jones R. 2015. Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.

Sarwat, M., Ahmad, A., Abdin, M.Z. 2013. Stress Signaling in Plants: Genomics and Proteomics Perspective, Volume 1, Springer.

HeribertHirt. 2010. Plant Stress Biology: From Genomics to Systems Biology, John Wiley.

Pandey, G.K. 2015. Elucidation of Abiotic Stress Signaling in Plants, Stringer.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception	02
2.	Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress;	04
3.	Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms;	02
4.	Biotic stress (insect and pathogen) resistance mechanism.	02
5.	Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants	02
6.	Hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism	02
7.	Adaptation to water logging, tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants.	02
8.	Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms molecular basis of thermo tolerance.	02
9.	Morphological and physiological changes in plants due to high and low light stresses - photo oxidation –plastid development. Characters	02

	of heliophytes and sciophytes – solar tracking – sieve effect and light channeling.	
10.	Heavy metal stress – Al and Cd stress - effects on plant growth and development, biotech Strategies to overcome heavy metal stress Nutrient stress effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects	02
11.	Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function	03
12.	Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management	04
13.	Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.	03
	Total	**32**

MBB-518 Gene Regulation 2+0

Objectives

To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

Theory

Unit I (8 Lectures)

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti- termination, Combinatorial control – Regulation of *lac*, *trp* and *ara* Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

Unit II (10 Lectures)

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain – Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Unit III (10 Lectures)

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo- switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function. Noncoding RNAs their impact, categories and role in gene regulation, chromatin assembly etc.

Unit IV (4 Lectures)

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.

Suggested Reading

Nelson, D. L. and Cox, M. M. 2017. Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York

Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T. 2017. Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc

Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine,M., & Lonick, R. 2014. Molecular Biology of the Gene, 7th Edition, Cold Spring Harbor Laboratory Press, New York.

Gardner, E. J., Simmons MJ and Snustad, D.P. 2006. Principles of Genetics (2006) 8th Edition. Wiley

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase	03
2.	Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control	02
3.	Regulation of lac, trp and ara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment	03
4.	Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain – Homeodomain	03
5.	Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers	03
6.	Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.	04
7.	Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents	04
8.	Ribo- switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function	03
9	Noncoding RNAs their impact, categories and role in gene regulation, chromatin assembly etc	03
10	Negative auto-regulation, Positive auto-regulation,	02
11	Bistable and Bimodal switch, Oscillating pattern of gene expression	02
	Total	**32**

Course Contents
Ph.D. (Agri.) Molecular Biology & Biotechnology

MBB-601 Plant Molecular Biology 3+0

Objectives

To provide in depth knowledge of recent developments of plant molecular biology and applications

To discuss case studies and success stories in agriculture and industry

Theory

Unit I (10 Lectures)

Model Systems in Plant Biology (Arabidopsis, Rice, etc.) Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear, Mitochondrial and Chloroplast Genomes. Cytoplasmic male sterility.

Unit II (12 Lectures)

Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis.

Unit III (12 Lectures)

Plant Developmental Processes, ABC Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms.

Unit IV (14 Lectures)

Abiotic Stress Responses: Salt, Cold, Heat and Drought.Biotic Stress Responses. Molecular Biology of Plant-pathogen Interactions, Molecular Biology of Rhizobium and Agrobacterium- Plant interaction. Role of programmed Cell Death in Development and Defense.

Suggested Reading

Buchanan, B.B., Gruissem, W. and Jones R. 2015. Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.

Slater, A., Scott, N.W., and Fowler, M.R. 2003. The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.

Walker, J.M., Rapley, R. 2008. Plant Biotechnology and Genetics: Principles, Techniques and Applications.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Model Systems in Plant Biology (Arabidopsis, Rice, etc.)	03
2.	Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear	04
3.	Mitochondrial and Chloroplast Genomes. Cytoplasmic male sterility	03
4.	Transcriptional and Post-transcriptional Regulation of Gene Expression	04
5.	Isolation of promoters and other regulatory elements, RNA interference	04
6.	Transcriptional Gene Silencing, Transcript and Protein Analysis	04
7.	Plant Developmental Processes, ABC Model of Floral Development	04
8.	Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms	04
9	Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development	04
10	Abiotic Stress Responses: Salt, Cold, Heat and Drought. Biotic Stress Responses	04
11	Molecular Biology of Plant-pathogen Interactions	04
12	Molecular Biology of Rhizobium and Agrobacterium- Plant interaction	03
13	Role of programmed Cell Death in Development and Defense	03
	Total	**48**

MBB-602 Plant Genome Engineering 3+0

Objectives

To discuss the specialized topics and advances in field of genetic engineering and application of molecular tools in breeding of specific crops.

Theory

Unit I (14 Lectures)

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation, and genomic tools for crop improvement. Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc.); edible vaccines, etc.

Unit II (12 Lectures)

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement

Unit III (12 Lectures)

Gene stacking; Pathway engineering; Marker-free transgenic development strategies; Genome editing: principles and methods, Development of genome edited plants; High throughput phenotyping of transgenic plants.

Unit IV (10 Lectures)

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Suggested Reading

Christou P and Klee H. 2004. Handbook of Plant Biotechnology. John Wiley & Sons.

Stewart Jr, C.N. 2016. Plant Biotechnology and Genetics: Principles, Techniques, and Applications. John Wiley & Sons.

Kirakosyan A and Kaufman PB. 2009. Recent Advances in Plant Biotechnology p. 409. Dordrecht: Springer.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker	02
2.	Transformation and genomic tools for crop improvement. Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc)	03
3.	Transformation and genomic tools for crop improvement. Genetic engineering for resistance against biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses	03
4.	Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency	03
5.	Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc.); edible vaccines, etc	03
6.	Recent developments in plant transformation strategies	04
7.	Role of antisense and RNAi-based gene silencing in crop improvement	04
8.	Regulated and tissue-specific expression of transgenes for crop improvement	04
9	Gene stacking; Pathway engineering; Marker-free transgenic development strategies	03
10	Genome editing: principles and methods, Development of genome edited plants	03
11	High throughput phenotyping of transgenic plants	03
12	Field studies with transgenic crops; Environmental issues associated with transgenic crops	04
13	Food and feed safety issues associated with transgenic crops	03
14	Risk assessment of transgenic food crops	03
	Total	**48**

MBB-603 Plant Omics and Molecular Breeding 3+0

Objectives

To discuss the specialized topics and advances in field of genomics and genomics assisted molecular breeding.

Theory

Unit I (12 Lectures)

Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping, high-throughput genotyping using automated platforms, genetic and physical mapping of genomes, study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies.

Unit II (12 Lectures)

Marker Assisted Breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection, whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB.

Unit III (12 Lectures)

Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction. Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions.

Unit IV (12 Lectures)

Study of the metabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.

Suggested Reading

Speicher, D.W. (Ed.). 2004. Proteome analysis: interpreting the genome. Elsevier.

Tomita, M. and Nishioka, T. (Eds.). 2006. Metabolomics: the frontier of systems biology. Springer Science and Business Media

Horst, L. and Wenzel, G. (Eds.). 2007. Molecular marker systems in plant breeding and crop improvement (Vol. 55). Springer Science and Business Media.

Stewart C.N. 2008. Plant Biotechnology and Genetics: Principles, Techniques and Applications.

Singh, B.D. and Singh, A.K. 2015. Marker-Assisted Plant Breeding: Principles and Practices Springer (India) Pvt. Ltd.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping	03
2.	High-throughput genotyping using automated platforms, genetic and physical mapping of genomes	03
3.	Study of population structure and kinship, association genetic analysis of QTL	03
4.	case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies	03
5.	Marker Assisted Breeding (MAB): Principles and methods, marker assisted foreground and background selection	05
6.	Marker assisted recurrent selection, whole genome selection, case studies in MAS	04
7.	Requirement for successful marker assisted breeding, cost of MAB	03
8.	Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome re-sequencing, DNA sequence comparison, annotation and gene prediction	04
9	Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing	04
10	Study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions	04
11	Study of the metabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers	05
12	Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS)	03
13	Correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome	04
	Total	**48**

MBB-604 Commercial Plant Tissue Culture 2+0

Objectives

To provide awareness into development of commercial scale plant tissue culture units.

To provide an insight into the commercial applications of plant tissue culture in agriculture, medicine and industry.

To educate about biosafety, regulatory as well as entrepreneurship opportunities.

Theory

Unit I (8 Lectures)

Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

Unit II (8 Lectures)

Production of useful compounds via, biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

Unit III (9 Lectures)

Value-addition by transformation; development, production and release of transgenic plants; patent, biosafety, regulatory, environmental and ethical issues; management and commercialization.

Unit IV (7 Lectures)

Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities) Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

Suggested Reading

Honda, H., Liu, C., Kobayashi, T. 2001. Large-Scale Plant Micropropagation. In: Zhong J.J. et al. (eds) Plant Cells. Advances in Biochemical Engineering/ Biotechnology, vol 72. Springer, Berlin, Heidelberg.

Bhojwani SS and Razdan MK. 1986. Plant tissue culture: theory and practice (Vol. 5). Elsevier.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation;	04
2.	Genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing	04
3.	Production of useful compounds via, biotransformation and secondary metabolite production	03
4.	Suspension cultures, immobilization,	03
5.	Examples of chemicals being produced for use in pharmacy, medicine and industry	02
6.	Value-addition by transformation; development, production and release of transgenic plants	03
7.	Patent, bio-safety, regulatory	03
8.	Environmental and ethical issues; management and commercialization	03
9	Project planning and preparation, economics (entrepreneurship, cost profit ratio),	02
10	Government policies (incubators, different facilitation projects, loan opportunities) Some case studies on success stories on commercial applications of plant tissue culture.	04
11	Visits to some tissue culture based commercial units/industries	01
	Total	**32**

MBB-605 Plant Microbe Interaction 2+0

Objectives

To discuss the specialized topics and advances in field of plantmicrobe interaction for understanding their potential in enhancing crop growth and development.

Theory

Unit I (8 Lectures)

Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbe-microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants onmicro organisms. Recognition processes and signal exchange, Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations: Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations

Unit II (8Lectures)

Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responsesin plants: pamp-triggered immunity effector-triggered susceptibility, qualitative resistance, r genes, structure and function, effector-triggered immunity, regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation

Unit III (8 Lectures)

Quorum sensing in bacteria, understanding microbiome, phytobiomes, dynamics, Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions. Industrial application of agriculturally important microbes.

Unit IV (8 Lectures)

Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions; induced resistance; non-host resistance. Systemic Acquired Resistance(SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants. Recognition mechanism and signal transduction during plant – pathogen interaction

Suggested Reading

Rangaswamy, G. Bhagyaraj. 1993. Agricultural Microbiology, Prentice Hall India.
Stacey, G., and Keen, N.T. (Eds.). 1996. Plant-microbe interactions. Springer Science &Business Media.
Dickinson M. 2005. Molecular Plant Pathology. Bios Scientific Press, Taylor and

Francisgroup.
Kosuge T and Nester EW. 1989. Plant-Microbe Interactions: Molecular and Genetic Perspectives. Vols I-IV. McGraw Hill.

González MBR and Gonzalez-López J. (Eds.). 2013. Beneficial plant-microbial interactions: ecology and applications. CRC press

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbe-microbe interactions leading to symbiotic, associative	02
2.	Endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants on microorganisms. Recognition processes and signal exchange	02
3.	Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations	02
4.	Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations	02
5.	Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in plants:	03
6.	Pamp-triggered immunity, effector-triggered susceptibility, qualitative resistance, r genes, structure and function, effector-triggered immunity,	02
7.	Regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation	03
8.	Quorum sensing in bacteria, understanding microbiome, phytobiomes, dynamics	02
9	Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions	05
10	Industrial application of agriculturally important microbes.	01
11	Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions	02

12	Induced resistance; non-host resistance. Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants	04
13	Recognition mechanism and signal transduction during plant – pathogen interaction	02
	Total	**32**

MBB-606 RNA Biology 1+0

Objectives

To discuss the specialized topics and advances in the field of Plant RNAs, their structure and role in cellular regulation and scope for crop improvement.

Theory

Unit I (4 Lectures)

RNA structure, functional evolution: RNA structure, types of RNA and function; Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation

Unit II (4 Lectures)

RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes; RNA splicing and editing; Translation and its regulation in prokaryotes and eukaryotes

Unit III (4 Lectures)

Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, riboswitches, CRISPER-Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA.

Unit IV (4 Lectures)

Epigenetic regulation. RNA-based gene silencing technologies and their applications for crop improvement

Suggested Reading

Elliott, D., and Ladomery, M. 2017. Molecular biology of RNA. Oxford University Press.

Rao, M.R.S. (Ed.) 2017. Long Non-Coding RNA Biology, Springer,

Donald, C.R., Hannon, G., Ares, M. and Nilsen, T.W. 2011. RNA: A Laboratory Manual, CSHL Press.

Maas, S. (Ed.). 2013. RNA Editing: Current Research and Future Trends. Horizon ScientificPress.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1.	RNA structure, functional evolution: RNA structure, types of RNA and function	02
2.	Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation	02

3.	RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes	02
4.	RNA splicing and editing; Translation and its regulation in prokaryotes and eukaryotes	02
5.	Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, riboswitches	01
6.	CRISPER-Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA.	03
7.	Epigenetic regulation	02
8.	RNA-based gene silencing technologies and their applications for crop improvement	02
	Total	**16**

MBB-607 Plant Hormones and Signaling 2+0

Objectives

To provide in-depth knowledge of plant hormone and their role in plant growth and development.

Theory

Unit I (12 Lectures)

Hormone Biosynthesis, Metabolism and its Regulation: Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism, Brassino-steroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism.

Unit II (12 Lectures)

Functioning of hormones in plant growth and development: Transport of Auxins, Induction of vascular tissues by Auxin, Hormones and the regulation of water balance, seed development and germination, Hormonal control of day length and senescence.

Unit III (12 Lectures)

Action of Hormones: Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signaling, PAMP and effector triggered immunity, systemic acquired resistance and SA signaling.

Unit IV (12 Lectures)

Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassino-steroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis: Quantitative analysis of plant hormones based on LC/MS.

Suggested Reading

Davies Jr. F. et al. 2017. Hart Mann and KRster's. Plant Propagation: Principles and Practices. Pearson.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Hormone Biosynthesis, Metabolism and its Regulation: Auxin biosynthesis and metabolism,	03
2.	Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis,	04
3.	Abscisic acid biosynthesis and metabolism, Brassino-steroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism	05
4.	Functioning of hormones in plant growth and development: Transport of Auxins	03
5.	Induction of vascular tissues by Auxin	03
6.	Hormones and the regulation of water balance, seed development and germination	03
7.	Hormonal control of day length and senescence	03
8.	Action of Hormones: Hormones in defense against insects and disease	03
9.	Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction	03
10.	Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signaling, PAMP and effector triggered immunity,	04
11.	Systemic acquired resistance and SA signaling	02
12.	Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction	03
13.	Gibberellin biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers,	03
14.	Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassino-steroid biosynthesis, catabolism and signal transduction.	03
15.	Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis: Quantitative analysis of plant hormones based on LC/MS	03
	Total	**48**

MBB-608 Computational and Statistical tools in Biotechnology 2+1

Objectives

To provide information on basic principles of computational biology and statistical tools used for data analysis

Theory

Unit I (8 Lectures)

Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g., HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, etc.)

Unit II (8 Lectures)

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack- knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling

Unit III (8 Lectures)

DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools

Unit IV (8 Lectures)

Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics

Practical (16)

1. Different Types of Databases and Database Search and Retrieval
2. DNA and Protein Sequence Analysis,
3. Similarity Searching and Multiple Alignments,
4. Gene Annotation,
5. Phylogenetic Analysis,
6. Sequence Analysis,
7. Protein Structure Prediction,
8. Analysis of Microarray Data,
9. Programming Languages in Bioinformatics.

Suggested Reading

Xiong J. 2012. Essential Bioinformatics, Cambridge University Press.

Andreas, D.B., and Ouellette B.F.F., (Eds) 2004. Bioinformatics: A Practical Guide to the

Analysis of Genes and Proteins 3rd Edition, Wiley Interscience.

Mount D. 2004. Bioinformatics: Sequence and Genome Analysis, 2nd Edition. By, CSHL Press.

Augen J. 2004. Bioinformatics in the Post-Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine.

Galperin M.Y. and Koonin E.V. (Eds) 2003. Frontiers in Computational Genomics.

Teaching Schedule
Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules	03
2.	Genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, etc.)	05
3.	Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis	02
4.	Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing	02
5.	Resampling techniques – Bootstrapping and Jack- knifing; Markov Models	02
6.	Hidden Markov Models, Bayesian estimation and Gibbs sampling	02
7.	DNA sequence retrieval system, various DNA and protein sequence file formats	02
8.	Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments	03
9.	DNA sequence analysis, different gene prediction models and gene annotation tools	03
10.	Protein sequence analysis and structure prediction	02
11.	Comparative genome analysis, phylogenetic analysis, gene expression analysis tools	03
12.	Programming languages and their applications in bioinformatics	03
	Total	**32**

Practical Schedule
Practical

Sr. No.	Topic	No. of Practical(s)
1.	Different Types of Databases and Database Search and Retrieval	01
2.	DNA and Protein Sequence Analysis	02
3.	Similarity Searching and Multiple Alignments	01
4.	Gene Annotation	01
5.	Programming Languages in Bioinformatics	03
6.	Phylogenetic Analysis	01
7.	Sequence Analysis	01
8.	Protein Structure Prediction	03
9.	Analysis of Microarray Data	03
	Total	**16**

List of Journals & e-Resources

1. Indian Journal of Biotechnology
2. Indian Journal of Genetics and Plant Breeding
3. Applied Microbiology and Biotechnology
4. Bioscience
5. Biotechnology Advances
6. Biotechnology and Bioengineering
7. Biotechnology and Genetic Engineering Reviews
8. Critical Reviews in Biotechnology
9. Current Opinion in Biotechnology
10. Journal of Biotechnology
11. Journal of Nanobiotechnology
12. Nature Biotechnology
13. Plant Biotechnology Journal Trends in Biotechnology
14. www.eagri.org
15. www.ncbi.nlm.nih.gov
16. www.international.neb.com
17. www.pubmed.ncbi.nlm.nih.gov
18. www.scihub.com
19. www.search.crossref.org
20. www.core.ac.uk
21. www.swissprot.org
22. www.pfam.xfam.org
23. www.agrocola.nal.usda.gov
24. www.europepmc.org
25. www.uniprot.org