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 sciences products 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.) Molecular Biology and Biotechnology

(b) Ph. D. Programmes

Ph.D. (Agri.) 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	Seminar	0+1
MBB 599	Research	0+30
	Total	**70**

***Core Courses; # New Courses**

Common compulsory 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. Biotechnology will 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 in Biological 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		Seminar I	0+1
MBB 692		Seminar II	0+1
MBB 699		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 of the 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, Wiley Blackwell

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

Lecture 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 and Types of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-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.

Lecture 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, tree of life, General structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; different kinds of cells in plant and animal tissues.

Unit II (8 Lectures)

Cell wall, cell membrane, structure and composition of bio-membranes, Structure and 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, mechanism of 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 coupled receptors, 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.

Lecture 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 (6 Lectures)

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.

Lecture 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: Electromobility shiftassay. 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, Coldspring harbour laboratorypress, NewYork.

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

Lecture 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, Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, Rocket Immunoelectrophoretic, Counter Current Immunoelectrophoretic, ELISA, LateX Agglutination, Immunohistochemistry.

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.,andSatiat-Jeunemaitre,B.2001.*PlantCellBiology:PracticalApproach*.OxfordUniversityPress,Oxford
Sawhney,S.K.,Singh,R.2014.*IntroductoryPracticalBiochemistry*,Alphascienceint ernationallimited.

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, Immunoprecipitation	03
15	Immunology and molecular diagnostics: Radiation Immunodiffusion, Immunoelectrophoretic, Rocket Immunoelectrophoretic	03
16	Immunology and molecular diagnostics: Counter Current Immunoelectrophoretic, ELISA, LateX Agglutination, Immunohistochemistry	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, Sequence analysis, 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 data bases and submission
3. Different Databases, BLAST eXercises.
4. Assembly of DNA and RNA Seq 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.

Lecture 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 (12 Lectures)

History of plant tissue culture, principle of Totipotency; Nutritional requirements of in vitro cultures & Tissue culture media; Plant hormones 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 (12 Lectures)

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 (12 Lectures)

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 Skoog medium.
2. Micro-propagation of plants by nodal and shoot tip culture.
3. Embryo culture to overcome incompatibility, Anther culture for haploid production.
4. Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
5. Acclimatization of tissue culture plants and establishment in green house.
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, NewYork, 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 & Business media

Lecture 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.	Plant hormones 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 (8 Lectures)

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

Unit II (8 Lectures)

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 (8 Lectures)

Microbial enzymes, role in various industrial processes, production of fin 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 (8 Lectures)

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.

Lecture 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-p Link software.
5. Genotyping by sequencing methods–Illumina genotyping platform.
6. Marker assisted breeding–MABB case studies quality traits in rice/maize.
7. Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data

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 Finger printing 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.

Lecture 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.

Lecture 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, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques-lymphoproliferation 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.

Lecture 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

CMI techniques- lympho proliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays	02
Apoptosis, Transgenic mice, Gene knock outs	02
Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants	03
Recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies	03
Immunity to Infection, Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity	03
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 of thiolate 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.

Lecture 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 H J and Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

Lecture 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, detergents etc	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.

Lecture 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.

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

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

Lecture 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
	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.	
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
Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function	03
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
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

Lecture 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.

Lecture 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.

Lecture 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.

Lecture 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.

Lecture 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 plant microbe 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 on microorganisms. 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 (8 Lectures)

Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in 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 Francis

group.
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

Lecture 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 Scientific Press.

Lecture 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 K Rster's. Plant Propagation: Principles and Practices. Pearson.

Lecture 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.

Lecture 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