DEPARTMENT OF AGRICULTURAL BIOTECHNOLOGY
FACULTY OF AGRICULTURE, BCKV, MOHANPUR, NADIA

Syllabus of Ph. D. in *Molecular Biology and Biotechnology*

Course Structure at a Glance

CODE	COURSE TITLE	CREDITS (L+P)
FIRST SEMESTER		
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
SECOND SEMESTER		
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
THIRD SEMESTER		
MBB 691	Doctoral Seminar I	0+1
SIX SEMESTER and onwards		
MBB 692	Doctoral Seminar II	0+1
MBB 699	Doctoral Thesis	0+75

* Core Courses

NB. Any other appropriate 500 series M. Sc.) Courses may also be opted as major course

Major Courses: **12** credits
(6 credits of core+6 credits of optional)
Minor Courses: **6** Credits
Supporting Course: **5** Credits
Doctoral Seminar: **2** Credits
Doctoral Thesis: **75** Credits.

Grand Total 100 Credits

DESCRIPTION OF COURSES

Ph.D in Molecular Biology and Biotechnology

I. **Course Title: Plant Molecular Biology**

II. **Course Code: MBB 601**

III. **Credit Hours:3+0**

IV. **Aim of the course**

- 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

V. **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.

VI. **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.,andFowler,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.

I. **Course Title: Plant Genome Engineering**

II. **Course Code: MBB 602**

III. **Credit Hours: 3+0**

IV. **Aim of the course**

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

V. **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 PlantBiotechnology*p.409. Dordrecht: Springer.

I. **Course Code: MBB603**

II. **Course Title: Plant Omics and Molecular Breeding**

III. **Credit Hours: 3+0**

IV. **Aim of the course**

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

V. 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.

VI. 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 andcrop Improvement* (Vol.55) Springer Science and Business Media.
- StewartC.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.

I. Course Title: Commercial Plant Tissue Culture

II. Course Code: MBB 604

III. Credit Hours:2+0

IV. Aim of the course

- 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.

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, bio-safety, 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.

V. Suggested Reading

- Honda,H.Liu,C.,Kobayashi,T.2001.*Large-Scale Plant Micropropagation*. In: ZhongJ.J. *etal*(eds) *Plant Cells. Advances in Biochemical Engineering/Biotechnology*, vol72.Springer, Berlin, Heidelberg.
- Bhojwani S.S and RazdanMK.1986. *Plant tissue culture: theory and practice* (Vol.5). Else vier.

I. Course Title: Plant Microbe Interaction

II. Course Code: MBB 605

III. Credit Hours: 2+0

IV. Aim of the course

To discuss the specialized topics and advances in field of plant microbe interaction forunderstandingtheirpotentialinenhancingcropgrowthanddevelopment.

V. 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: Ecto mycorrhizae, Endo mycorrhizae with particular emphasis to AM fungi, Ecto-endo mycorrhizae. 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 III (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

VI. Suggested Reading

- Rangaswamy, 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 MB Rand Gonzalez-LópezJ. (Eds.).2013. *Beneficial plant-microbial interactions: ecology and applications*. CRC press.

I. **Course Title: RNA Biology**

II. **Course Code: MBB 606**

III. **Credit Hours: 1+0**

IV. **Aim of the course**

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.

V. **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

VI. **Suggested Reading**

- Elliott, D.,and Ladomery,M.2017.*MolecularbiologyofRNA*.OxfordUniversityPress.
- Rao,M.R.S.(Ed.)2017.*LongNon-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.

I. **Course Title: Plant Hormones and Signaling**

II. **Course Code: MBB 607**

III. **Credit Hours: 2+0**

IV. **Aim of the course**

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

V. **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, Brassinosteroid 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. Brassinosteroid biosynthesis, catabolism and signal transduction. Striga lactone biosynthesis, transport and signaling in plant-parasitism and symbiosis. Methods of Plant Hormone Analysis**:** Quantitative analysis of plant hormones based on LC/MS.

VI. Suggested Reading

- Davies Jr. F. *etal*.2017. Hart Mann and KRster's. *Plant Propagation: Principles and Practices.* Pearson.

I. Course Title: Computational and Statistical tools in Biotechnology

II. Course Code: MBB 608

III. Credit Hours: 2+1

IV. Aim of the course

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

V. 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, Uni genes, 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, primer designing

VI. Practical (16)

- Different Types of Databases and Database Search and Retrieval,
- DNA and Protein Sequence Analysis,
- Similarity Searching and Multiple Alignments,
- Gene Annotation,
- Phylogenetic Analysis,

- Visualization of protein 3D structure
- Protein structure prediction
- Designing of primer
- Handling of statistical software for analysis of biological data

VII. Suggested Reading

- XiongJ.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 Inter science.
- MountD.2004. *Bioinformatics: Sequence and Genome Analysis*, 2ndEdition. By, CSHL Press.
- AugenJ.2004. *Bioinformatics in the Post- Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine*.
- Galperin M.Y. and Koonin E.V.(Eds)2003.*Frontiersin Computational Genomics.*