MASTER OF SCIENCE
IN
PLANT MOLECULAR BIOLOGY AND BIOTECHNOLOGY

TWO YEAR FULL TIME PROGRAMME

Revision of Syllabus

1. Meetings of the Departmental Committee on restructuring of M.Sc. Course held on 24.6.2008 and 9.10.2008
2. Course was discussed in the Departmental Staff Council meetings held on 30.9.2008, 15.10.2008, 6.11.2008, 17.11.2008, 10.12.2008 and 23.1.2009.
3. Comments of Experts on the Course received vide letters no. AR(PVCO)/09/90, dated 26.2.2009 and PVCO/Syllabus/2009/022, Diary no. 404 from PVC discussed and responses finalized in meeting of the Departmental Staff council on 17.3.2009.
4. Syllabus approved by meeting of Committee of Courses held on 14.5.2009
5. Syllabus approved in the meeting of the Faculty of Interdisciplinary & Applied Sciences held on 22.5.2009.
6. The Revised Syllabus also has been approved by the Standing Committee on 10th June, 2009.

DEPARTMENT OF PLANT MOLECULAR BIOLOGY
FACULTY OF INTERDISCIPLINARY AND APPLIED SCIENCES
UNIVERSITY OF DELHI, SOUTH CAMPUS

NEW DELHI – 110 001
INDIA

MASTER OF SCIENCE

IN

PLANT MOLECULAR BIOLOGY AND BIOTECHNOLGY

TWO YEAR FULL TIME PROGRAMME

The **M.Sc. PMBB Programme** is of two years duration and is divided into **two parts,** Part I and Part II. Each part has **two Semesters.**

Semester-1 will have **four theory papers of 100 marks each** including two interdisciplinary papers and **one practical** paper based on theory papers of **200 marks. Semester-2** also has **four theory papers of 100 marks each and one practical paper of 200 marks. Semester-3** has **four theory papers of 100 marks each** and **one practical paper of 200 marks. Semester-4** has only **Dissertation.** There will be no practical in this Semester-4**. Dissertation for 600 marks** will be in Semester-4. Dissertation will carry marks for continuous assessment, dissertation/thesis its presentation and viva-voce. This will be evaluated at the end of Semester-4.

All theory, practicals and dissertation will have **30% marks reserved for Internal Assessment (IA). Each theory examination** will be of **three hours** durations and **practical examination will be for (8+8 hours) spread on two days.**

Teaching time allotted to each paper shall be 2 period for theory and 6 period for practicals and 1 period for tutorial per paper / per week.

The detailed syllabus for each paper is appended with a list of suggested readings which would be further supplemented with other books/papers and be modified as new material becomes available. While the students will be asked to refer to older editions of books for some of the topics, the books generally prescribed would consist of the latest editions. To reflect the same, edition numbers have not been mentioned in the Suggested Readings.

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RULES, REGULATIONS AND COURSE CONTENTS

Department of Plant Molecular Biology

FACULTY OF INTERDISCIPLINARY AND APPLIED SCIENCES
UNIVERSITY OF DELHI SOUTH CAMPUS
NEW DELHI-110021
2009

MASTER OF SCIENCE
IN
PLANT MOLECULAR BIOLOGY AND BIOTECHOLOGY

TWO YEAR FULL TIME PROGRAMME

The M. Sc. Course in Plant Molecular Biology and Biotechnology at Plant Molecular Biology Department (PMB), UDSC has been designed to expose students to the latest developments in the exciting and burgeoning areas of modern Plant Sciences. This course will prepare students to take research in Plant Molecular Biology and allied areas as a possible career option as well as will enable generation of manpower for the emerging Plant Biotechnology industry.

The Course comprises Classroom Teaching, Laboratory Practicals, Tutorials in the form of Seminars and a Dissertation. Students will be offered a total of twelve Theory Papers, of which ten will be taught in the PMB Department and two in sister Departments within the Faculty of Interdisciplinary and Applied Sciences (FIAS), UDSC. Each Paper taught in PMB Department will be of six credits (two credits for Theory classes, three credits for Practical classes and one credit for Tutorial).

The twelve Theory Papers will be uniformly spread over first three Semesters. The first semester has two Papers offered by the PMB Department, one dealing with Basic Concepts and Techniques in Molecular Biology and the other dealing with Molecular Cell Biology. A Paper on Proteins – Structure, Folding and Engineering and another on Immunology will also be taught in the first semester. In the second semester, the four Papers offered are Gene Expression in Prokaryotes, Molecular Basis of Plant Growth and Development, Plant Biochemistry and Metabolism and Introduction to Bioinformatics. The Paper Introduction to Bioinformatics offered by PMB Department will also be open to students of other Departments of the FIAS. The third semester will have four advanced Papers, namely Structure and Function of Eukaryotic Genome, Pattern Formation and Differentiation in Plants, Molecular Breeding and IPR related issues and Plant Biotechnology. Large number of Practicals related to the all Theory Papers have been designed to provide students hands-on training. Tutorials in each Paper will consist of Seminars on selected topics to be delivered by students. In the fourth semester, students will devote their entire time for a Dissertation under the guidance of faculty members. Dissertation work will involve detailed studies pertaining to a specific research problem and will provide direct experience to the students of conducting research in a modern laboratory environment.

Students will be evaluated on the basis of written examinations and practical tests to be held at the end of each semester and also on the basis of tutorials and class tests throughout the semester for each Paper.

MASTER OF SCIENCE
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AFFILIATION

The proposed programme shall be governed by the Department of Plant Molecular Biology, Faculty of Interdisciplinary and Applied Sciences (F.I.A.S.), University of Delhi South Campus, New Delhi-110021.

PROGRAMME STRUCTURE

The Master of Science Programme in Plant Molecular Biology and Biotechnology is divided into two parts as under. Each part will consist of two Semesters to be known as Semester-1 and Semester-2.

Part I	First Year	Semester-1	Semester-2
Part II	Second Year	Semester-3	Semester-4

The schedule of papers prescribed for various semesters shall be as follows:

PART I : Semester-1

Paper Biochem 0701 - Proteins-Structure, Folding and Engineering
Paper PMBB 0702 - Molecular Cell Biology
Paper PMBB 0703 - Basic Concepts and Techniques in Molecular Biology
Paper Microb 0704 - Immunology
Practical Course 0705

PART I : Semester-2

Paper PMBB 0801 - Gene Expression in Prokaryotes
Paper PMBB 0802 - Molecular Basis of Plant Growth and Development
Paper PMBB 0803 - Plant Biochemistry and Metabolism
Paper PMBB 0804 - Introduction to Bioinformatics
Practical Course 0805

PART II : Semester-3

Paper PMBB 0901 - Structure and Function of Eukaryotic Genome
Paper PMBB 0902 - Pattern Formation and Differentiation In Plants
Paper PMBB 0903 - Molecular Breeding and IPR related issues
Paper PMBB 0904 - Plant Biotechnology
Practical Course 0905

PART II: Semester-4

Paper PMBB 1001 - Dissertation

SCHEME OF EXAMINATIONS

1. English shall be the medium of instruction and examination.

2. Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi.

3. Each paper will of 6 credits consisting of 2 Theory (Th) + 3 Practicals (P) + 1 Tutorial (T). Therefore the pattern to be followed would be 1Th + 3P + 1T. Total number of credits in a semester will be 24. Total number of credits for the entire course will be 96.

4. The system of evaluation shall be as follows:

PART I: SEMESTER-1

	Duration (Hours)	Maximum Marks
Paper Biochem 0701*: Proteins-Structure, Folding and Engineering	(3)	100
Paper PMBB 0702 : Molecular Cell Biology	(3)	100
Paper PMBB 0703 : Basic Concepts and Techniques in Molecular Biology	(3)	100
Paper Microb 0704* : Immunology	(3)	100
Paper PMBB 0705 : Practical Course	(16)	200
Total Maximum Marks		600

PART I: SEMESTER-2

	Duration (Hours)	Maximum Marks
Paper PMBB 0801 : Gene Expression in Prokaryotes	(3)	100
Paper PMBB 0802 : Molecular Basis of Plant Growth and Development	(3)	100
Paper PMBB 0803 : Plant Biochemistry and Metabolism	(3)	100
Paper PMBB 0804 : Introduction to Bioinformatics	(3)	100
Paper PMBB 0805 : Practical Course	(16)	200
Total Maximum Marks		600

PART II: SEMESTER-3

		Duration (Hours)	Maximum Marks
Paper PMBB 0901	: Structure and Function of Eukaryotic Genome	(3)	100
Paper PMBB 0902	: Pattern Formation and Differentiation in Plants	(3)	100
Paper PMBB 0903	: Molecular Breeding and IPR-related issues	(3)	100
Paper PMBB 0904	: Plant Biotechnology	(3)	100
Paper PMBB 0905	: Practical Course	(16)	200
Total Maximum Marks			600

PART II: SEMESTER-4

	Duration (Hours)	Maximum Marks
Paper PMBB 1001: Dissertation**		600
Total Maximum Marks		600

Each theory paper will consist of written examination (70 marks) and internal assessment (30 marks). Internal assessment will consist of seminar presentations (12 marks), class-tests (12 marks) and attendance (6 marks). The practical examination will consist of attendance (10 marks), Practical records (50 marks), Viva-voce/internal assessment (40 marks) and Practical examination (100 marks).

* The two optional papers will be offered by Department of Biochemistry (Paper Biochem. 0701) and Department of Microbiology (Paper Microb. 0704).

** Dissertation work will consist of internal evaluation by the concerned supervisor based on general performance during the Project work as internal assessment (180 marks), and project work (320 marks) and seminar/viva-voce (100 marks) evaluated by a Board comprising all teachers in the Department.

SCHEME OF EXAMINATIONS

1. English shall be the medium of instructions and examination.

2. Examinations shall be conducted at the end of each Semester as per the Academic Calendar notified by the University of Delhi.

3. The system of evaluation shall be as follows:

   3.1 Each theory paper will carry 100 marks of which 30% marks shall be reserved for internal assessment based on classroom participation, seminar, term courses, tests, viva-voce and laboratory work and attendance. The weightage given to each of these components shall be decided and announced at the beginning of the semester by the individual teacher responsible for the course. Any student who fails to participate in classes, seminars, term courses, test, viva-voce, practical and laboratory work will be debarred from appearing in the end-semester examination in the specific course and no internal Assessment marks will be awarded. His/her Internal Assessment marks will be awarded as and when he/she attends regular classes in the courses in the next applicable semester. No special classes will be conducted for him/her during other semesters.

   3.2 Each practical based on theory paper will be of 200 marks of which 30% marks will be reserved for internal assessment. The duration of written examination for each paper shall be three hours and Practical examination shall be for two days (8+8 hours) duration in total.

   3.3 As regards Project Work/Dissertation (PMBB 1001), the scheme of evaluation shall be as follows:

      3.3.1 Project Work/Dissertation shall be in Semester-4. It will be evaluated at the end of Semester-4.

      3.3.2 The candidate has to submit dissertation in a bound form at the end of Semester-4. Total marks for dissertation shall be 600 and evaluation will be as follows:

Continuous evaluation (IA)	=	180 marks
Experimental work and Dissertation	=	320 marks
Presentation and viva-voce	=	100 marks
Total	=	600 marks

4. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examination. Regular as well as Ex-Students shall be permitted to appear/reappear/improve in courses of odd semesters only at the end of odd semesters and for even semester with the even.

PASS PERCENTAGE

Students are required to pass separately both in theory and practical examinations. Minimum marks for passing the examination shall be 45% in aggregate in theory courses, 45% in practical courses and 45% marks in dissertation by scoring at least 40% in each theory paper.

PROMOTION CRITERIA

SEMESTER TO SEMESTER: Within the same Part, the candidate will be promoted from a Semester to the next Semester (Semester-1 to Semester-2 and Semester-3 to Semester-4), provided the candidate has passed at least two of the papers of the current semester by securing at least 40% marks in each paper.

Note: 1. A candidate who does not appear in a theory paper will be allowed ONLY ONE more attempt to pass the paper. No further attempts for improvement will be allowed.

2. A candidate will not be allowed to reappear (even if he/she is absent) in the practical examination.

PART I TO PART II: Admission to Part II of the program shall be open to only those students who have fulfilled the following criteria:

1. have scored at least 45% marks in the practical papers of both Semester-1 and -2 taken together,
2. have passed at least 75% of the theory papers (6 papers) offered in courses of Part I comprising of Semester-1 and Semester-2 by securing at least 40% marks in each of these six papers and
3. have secured at least 45% in aggregate of all theory papers of Part I.

Note: The candidate however will have to clear the remaining papers while studying in Part II of the programme.

AWARD OF DEGREE

A candidate will be awarded M.Sc. degree at the end of Semester-4 provided he/she has:

1. passed all the theory papers of Part I (Semester-1&-2) and Part II (Semester-3&-4) by securing at least 40% marks in each paper and has also obtained at least 45% in aggregate of Part I & Part II,
2. passed the practical examination by securing at least 45% in aggregate of Part I and Part II, separately and
3. passed dissertation by securing at least 45% marks.

Candidates who have fulfilled criteria 2 and 3 (wherever applicable) but not criteria 1:

1. Can reappear for theory papers as per University rules.

   A candidate must pass the M.Sc. examination within span period.

2. No candidate shall be allowed to reappear for practical or dissertation.

SCOPE FOR IMPROVEMENT – As per University rules.

DIVISION CRITERIA

Successful candidates will be classified on the basis of the combined results of Part I and Part II examinations as follows:

Candidates securing 60% and above	:	1st Division
Candidates securing 50% and above but less than 60%	:	2nd Division
Candidates securing 45% and above but less than 50%	:	Pass

SPAN PERIOD

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of **four years** from the date of admission to the Part I/Semester-1 of the M.Sc. program.

ATTENDANCE REQUIREMENT

No student shall be considered to have pursued a regular course of study and be eligible to take examination unless he/she has attended 75% of the total number of lectures, tutorials, seminars and practicals conducted in each semester, during his/her course of study. Under special circumstances, the Head of the Department may allow students with at least 65% attendance to take the examination.

SEMESTER SYSTEM COURSE DETAILS

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COURSE CONTENT FOR EACH PAPER

An outline of course content is provided below along with the list of reading. As far as possible, the latest editions of all books should be consulted.

Paper Biochem 0701. ***PROTEINS - STRUCTURE, FOLDING & ENGINEERING***
(Offered by Department of Biochemistry, F.I.A.S., UDSC)

- **Introduction** -- Genesis; History; Importance and Significance of proteins; Functional diversity, Ubiquity, Classes and Dynamism; Structure-function relationship; Key Features.
- **Amino Acids as Constituents** -- Acid/Base properties; Bifunctional monomers,;Polarity; Classification; Chirality and stereochemistry; pK_a; Codes; Ways of representation, Essential, non-essential, non-standard and non-proteinogenic amino acids.
- **Physico-chemical Interactions in Biological Systems** -- Covalent and non-covalent interactions; Importance of water; Accessible surface area; Importance of weak interactions.
- **Levels of Protein Structure** -- Primary structure - importance of amino acid sequence; Peptide bond and polypeptide - polarity, direction, backbone and side chains; Importance of H-bonding, cross-linking in polypeptides, flexibility and conformational restrictions, characteristics of peptide bond, trans- and cis-peptide bonds, rotation of adjacent peptide bonds, dihedral angles - phi and si, Ramachandran plot, thermodynamic considerations. Secondary structure - H-bonding scheme, alpha-helices, screw sense, diversity in alpha-helices, alpha-helical wheel, helix capping, beta-stand and sheet, types of beta-sheet, Ramachandran plots, turns and loops, importance of loops. Tertiary structure - general properties and characteristics; Myoglobin structure as model; Supersecondary structures; Protein Data Bank (PDB). Quaternary structure - concept of subunits and protomers; Kinds of subunit association; Importance of quaternary structure; Various examples.
- **Fibrous and Globular proteins, Structural Features of Membrane proteins**
- **Protein Classification and Structure Prediction** -- Importance, assumptions, classes and databases; Terminologies like domains, motifs, folds, architecture, active site; Examples; Secondary structure prediction; Theories and tools; Tertiary structure prediction.
- **Protein Folding** -- Genesis and definition; The “protein folding problem”; Terminologies; Denaturants and their mode of action; Anfinsen’s classical experiment; Propensities of amino acids to form secondary structure; Folding curves and transitions; Cooperative protein folding; Equilibrium and kinetic intermediates; Models and Theories of protein folding; Assisted protein folding; Misfolding and diseases; Current status.
- **Protein Engineering** -- Basic principles; Types and Methods; Strategies in protein engineering (directed evolution, comparative design, rational design); Applications.
- **Solvent Engineering, Solubility / stability of Proteins in Solutions** -- Interaction of protein, water and solvent; Importance of solvents; Factors affecting aqueous solubility; Physical basis for protein denaturation/ stability; Effect of primary structure on

stabilization; Preferential binding and preferential hydration models; Thermodynamics of unfolding; Rationalizing stabilities of folded conformations; Various stabilizers.

- **Techniques to Investigate Protein Conformation and Folding** -- Spectroscopic methods - absorbance, fluorescence (ANS binding), circular dichroism; Electrophoretic methods - limited proteolysis and SDS-PAGE, transverse urea gradient gel electrophoresis; Hydrodynamic methods - gel filtration, analytical ultracentrifugation; Calorimetric methods – differential scanning calorimetry (DSC); Structural methods - NMR.

List of Readings:

1. **Sheehan, D.** (2009) Physical Biochemistry: Principles and Applications. John Wiley & Sons Ltd., UK.
2. **Branden, C. I. and Tooze, T.** (1999) Introduction to Protein Structure. Garland Publishing, USA.
3. **Lesk, A. M.** (2004) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
4. **Creighton, T.E.** (1983) Proteins: Structures and Molecular Properties. W.H. Freeman and Co., USA.
5. **Pain, R.H.** (2000) Mechanism of Protein Folding. Oxford University Press, UK.
6. **Arai, M. and Kuwajima, K.** (2000) Advances in Protein Chemistry. Academic Press, USA.
7. **Cavanagh, J., Fairbrother, W.J., Palmer, A.G., Rance, M. and Skelton, N. J.** (2007) Protein NMR Spectroscopy: Principles and Practice. Academic Press, USA.
8. **Lutz, S. and Bornschesser, U. T.** (2008) Protein Engineering Handbook. Wiley-VCH, Germany.
9. **Mount, D.W.** (2004) Bioinformatics Sequence and Genome Analysis. Second Edition. CSHL Press, USA.
10. **Uversky, V. N. and Fink, A.L.** (2006) Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews). Springer, USA.

Paper PMBB 0702. ***MOLECULAR CELL BIOLOGY***

- **Investigating the Cell** -- Cell theory; Microscopy (staining for light, fluorescence, confocal and electron microscopes); Advance imaging techniques (live cell imaging, co-localization).

- **Cell Wall** -- Cell wall composition and architecture; Biogenesis and assembly; Dynamic aspects of cell wall during growth and differentiation.

- **Membrane Systems** -- Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Sensory physiology; Endo- and exo-cytosis; Membrane proteins & carbohydrates and their significance in cellular recognition.

- **Mitochondria** -- Structure; Organization; Structure-function relationship; Mitochondrial genetic machinery and male sterility; Biogenesis, origin and evolution.

- **Chloroplast and Photosynthetic Systems** -- Structure; Organization; Structure-function relationship; Chloroplast genetic machinery and its significance; Chloroplast biogenesis, origin and evolution.

- **Nucleus** -- Structure and function (architecture); Chromatin organization and packaging; Macromolecular trafficking.

- **Endomembrane Systems** -- Structure and function of Golgi apparatus, lysosomes and endoplasmic reticulum and microbodies; Membrane maturation and specialization.

- **Cytoskeleton and Cellular Motility** -- Organization and role of microtubules and microfilaments; Actin-binding proteins and their significance; Molecular motors; Intermediate filaments.

List of Readings:

1. **Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P.** (2002) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.

2. **Karp, J.G.** (2007) Cell and Molecular Biology. John Wiley & Sons, USA.

3. **Kleinsmith, L.J. and Kish, V.M.** (1996) Principles of Cell & Molecular Biology. Second Edition. Harper Collins College Publishers, USA.

4. **Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J.** (Eds). (2000) Molecular Cell Biology. Freeman & Co., USA.

5. **Pollard, T.D. and Earnshow, W.C.** (2002) Principles of Cell and Molecular Biology, Saunders, USA.

6. **Ruzin, S.E.** (1999) Plant Microtechnique and Microscopy. Oxford University Press, USA.

Paper PMBB 0703. ***BASIC CONCEPTS AND TECHNIQUES IN MOLECULAR BIOLOGY***

- **Molecules of Life** -- Occurrence, structure, classification and functions of biomolecules: carbohydrates, lipids, proteins and nucleic acids; Basics of DNA and protein synthesis.

- **Bioenergetics** -- Basic concepts of chemical reactions, thermodynamics, entropy, enthalpy, free energy and redox reactions; Mechanism of phosphorylation coupled to electron transport; Storage and utilization of energy.

- **Physicochemical and Separation Techniques** -- Principles and applications of spectrometry, centrifugation, chromatography, electrophoresis, radioactivity measurements.

- **Principles, Tools and Techniques of Recombinant DNA Technology** -- Gene cloning, restriction enzymes and nucleic acid modifying enzymes; Vectors - plasmids, phages, cosmids, shuttle vectors, artificial chromosomes, plant viruses and other advanced vectors; cDNA and genomic libraries - construction, screening methods and applications; PCR and its applications; DNA and protein sequencing methods; Techniques for studying gene expression and inter-biomolecular interactions.

List of Readings:

1. **Brown, T.A.** (2007) Genomes 3. Garland Science Publishing, USA.

2. **Metzler, D.E.** (2000) Biochemistry. Academic Press, USA.

3. Primrose, S.B. and Twyman, R.M. (2006) Principles of Genetic Manipulation and Genomics. Seventh Edition. Blackwell Publishing, USA.

4. Voet, D. and Voet, J.G. (2004) Biochemistry. John Wiley & Sons, USA.

5. **Winnacker, E-L.** (1987) From Genes to Clones. VCH Publishers, USA.

Paper Microb 0704. ***IMMUNOLOGY***
(Offered by Department of Microbiology, F.I.A.S., UDSC)

- **Three Fundamental Concepts in Immunology:** Specificity, discrimination of self from non-self and memory.

- **Immune Cell Receptors:** Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, MadCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR); Markers of suppressor / regulatory cells - $CD4^+$ $CD25^+$ $Foxp3^+$ T_{reg} , iNKT.

- **Genetic Organization:** Organization of the genes for B and T cell receptors; Genetic organization of MHC-I and MHC-II complex (both HLA and H-2); Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors; Peptide loading and expression of MHC-I and MHC-II molecules.

- **Immune Response and Signaling:** Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, 1L-10, 1L-12, IL-17, TGFβ; Cell signaling through MAP kinases and NF-κB.

- **Tolerance and Autoimmunity:** Central and peripheral tolerance and their mechanism; Mechanisms of autoimmunity; Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), experimental autoimmune encephalitis (EAE); Infections leading to autoimmune diseases.

- **Immunological Disorders and Hypersensitivity:** Deficiencies / defects of T cells, B cells, complement and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

- **Transplantation and Tumor Immunology:** Alloreactive response; Graft rejection and GVHD; HLA-matching; Transgenic animals for xenotransplantation; Tumor antigens, immune response to tumors and immunotherapy of tumors.

List of Readings:

1. **Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby J.** (2006) Kuby Immunology. WH Freeman & Co., USA.
2. **Abbas, A.K., Lichtman, A.H. and Pillai, S.** (2007) Cellular and Molecular Immunology. Saunders Elsevier, USA.
3. **Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J.** (2005) Immunobiology: The immune system in health and disease. Garland Science Publishing, USA.
4. **Levinson, W. and Jawetz, E.** (2001) Medical Microbiology and Immunology. Lange Publication, USA.

5. **Paul, W.E.** (2000) Fundamental Immunology. Raven Press, USA.
6. **Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M.** (2006) Roitt's Essential Immunology. Eleventh Edition. Blackwell Publishing/Oxford Univ. Press, UK.

PMBB 0705 Practical Course

List of Practicals

- Isolate chloroplasts from the given plant material, quantitate proteins using dot blot assay, and resolve the proteins by SDS-PAGE to identify major chloroplast proteins.

- Isolate mitochondria from the given plant material and demonstrate the activity of its marker enzyme, succinate dehydrogenase.

- To study the effect of physical and chemical permeabilizing agents on membrane permeability.

- To isolate protoplasts from flower petals and leaves of different plants and demonstrate protoplast fusion via PEG**.**

- To learn basics of microscopy and differentiate dicot and monocot morpho- histological characteristics by using respective model systems, viz. Arabidopsis and rice. And visualization of GFP expression in transgenic Arabidopsis by using fluorescence microscope.

- Perform (i) Desalting of proteins and (ii) resolve proteins of various molecular weights (between 20 to 200 kDa) using gel filtration chromatography.

- To extract proteins from the given plant material and estimate soluble protein content by Bradford method.

- To resolve soluble proteins by discontinuous, SDS-gel electrophoresis under denaturing conditions followed by staining with Coomassie Brilliant Blue R-250.

- To resolve soluble proteins by gradient gel electrophoresis under denaturing conditions, for optimal separation of LMW and HMW proteins followed by staining with highly-sensitive silver staining method.

- To isolate native proteins for resolving isozymes using native, non- denaturing polyacrylamide gel electrophoresis.

- To prepare electrocompetent cells of E. coli and transform them by plasmid using electroporator.

- To isolate plant DNA from different sources and perform Southern hybridization after digestion with restriction enzymes.

- To perform amplification of cDNA by PCR and to perform 3'-RACE (Rapid amplification of cDNA ends).

- To clone a DNA fragment in plasmid vector by ligation, transformation of ligation mix in *E. coli* cells and selection of transformants.

- To perform ‘Colony PCR’ to screen for the positive *E. coli* transformants containing the ligated product and perform restriction digestion of the positive clone.
- To prepare yeast competent cells and transform yeast cells with plasmid DNA.

Paper PMBB 0801. ***GENE EXPRESSION IN PROKARYOTES***

- **Historical and General Aspects** -- Basic discoveries on genetic material; Genotype to phenotype.

- **Genome Replication and Maintenance** -- Basic principles of perpetuation and maintenance of genomic integrity; Biochemical and genetic tools to study replication; DNA polymerases and accessory proteins; Control of replication of chromosomes and extra-chromosomal elements; Mutations; Recombination; Repair and retrieval systems; Transposable elements.

- **Regulation of Transcription** -- Discovery of RNA; Operon concept; Promoters and other control elements; RNA polymerases and accessory factors; Transcriptional controls; Controls at transcription termination; Control of gene expression in bacteriophages and viruses.

- **Translation and its Regulation** -- Structure of ribosome and comparative studies in eukaryotes; tRNA; Genetic code; Translational and post-translational control; Codon bias.

List of Readings:

1. **Griffiths, A.J., Gelbart, W.M., Lewontin, R.C. and Miller, J.H.** (1999) Modern Genetic Analysis. W. H. Freeman, USA.
2. **Lewin, B**. (2008) Genes IX. Jones and Bartlett Publishers, Inc., USA.

3. **Wagner, R.** (2000) Transcription Regulation in Prokaryotes. Oxford University Press, UK.

4. Watson, J.W., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2004) Molecular Biology of Gene. Pearson Education, USA.

5. **Weaver, R.F.** (2005) Molecular Biology. McGraw Hill, UK.

Paper PMBB 0802. ***MOLECULAR BASIS OF PLANT GROWTH AND DEVELOPMENT***

- **Light Control of Plant Development** -- Skotomorphogenesis and photomorphogenesis; Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants.

- **Floral Induction and Development** -- Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation.

- **Biosynthesis of Plant Hormones and Elicitors** -- **S**tructure and metabolism of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, salicylic acid, jasmonates and related compounds.

- **Molecular Mechanism of Hormone Action** -- Hormone signal perception, transduction and regulation of gene expression during plant development; Role of mutants in understanding hormone action; Phospholipids and Ca^{2+}-calmodulin cascade; MAP kinase cascade; Two-component sensor-regulator system.

- **Seed Development, Dormancy and Seed Germination** -- Hormonal control of seed development; Seed maturation and dormancy; Hormonal control of seed germination and seedling growth; Mobilization of food reserves during seed germination.

- **Senescence and Programmed Cell Death (PCD)** -- Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

List of Readings:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. -Eds. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, USA.

2. Heldt, H.W. (2005) Plant Biochemistry. Academic Press, USA.

3. Hopkins, W.G. and Huner, N.P.A. (2004) Introduction to Plant Physiology. John Wiley, UK.

4. Srivastava, L.M. (2002) Plant Growth and Development: Hormones and Environment. Academic Press, USA.

5. Taiz, L. and Zeiger, E. -Eds. (2006) Plant Physiology. Sinauer Associates Inc. Publishers, USA.

Paper PMBB 0803. ***PLANT BIOCHEMISTRY AND METABOLISM***

- **Carbon Assimilation** -- Light absorption and energy conversion; Calvin Cycle; Hatch-Slack pathway; Reductive pentose phosphate pathway; Carbon dioxide uptake and assimilation; Photorespiration; Glycolate metabolism.

- **Biological Oxidation and Release of Energy** -- Glycolytic pathway; Kreb's cycle; High energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis; Pentose phosphate shunt pathway.

- **Metabolism of Macromolecules** -- Biosynthesis and inter-conversion of carbohydrates; Biosynthesis, inter-conversion and degradation of lipids; Metabolism of nucleotides and amino acids.

- **Nitrogen, Sulphur and Phosphorus Metabolism** -- General aspects of nitrogen economy; Nitrate reduction; Pathways of ammonia assimilation; Reductive amination; Trans-amination; Regulation of nitrogen assimilation; Uptake, transport and assimilation of sulphate and phosphate.

- **Nitrogen Fixation** -- Symbiotic and non-symbiotic nitrogen fixation; Role of lectins; *nod* genes; *nif* genes; Structure, function and regulation of nitrogenase; Leghaemoglobin; Nodulins; Regulation and enhancement of nitrogen fixation.

- **Long-distance Transport Mechanisms** -- Turgor and stomatal movements; Solute movement; Source-sink relationship; Water relations.

- **Secondary Metabolism --** Importance of secondary metabolites; Biosynthesis of phenolic compounds, isoprenoids, alkaloids and flavonoids.

List of Readings:

1. **Buchanan, B., Gruissem, W. and Jones, R.** -Eds. (2000) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists, USA.

2. **Dey, P.M. and Harborne, J.B.** -Eds. (1997) Plant Biochemistry. Academic Press, USA.

3. **Metzler, D.E.** (2007) Biochemistry. Academic Press, USA.

4. **Nelson D.L. and Cox, M.M.** (2008) Principles of Biochemistry. W H Freeman & Co., USA.

5. Stryer L., Berg, J.M. and Tymoczko, J.L. (2006) Biochemistry. W.H. Freeman & Co., USA.

Paper PMBB 0804. ***INTRODUCTION TO BIOINFORMATICS***

- **Introduction to Computers and Bioinformatics** -- Types of operating systems, concept of networking and remote login, basic fundamentals of working with unix.

- **Biological Databases** -- Overview, modes of database search, mode of data storage (Flat file format, db-tables), flat-file formats of GenBank, EMBL, DDBJ, PDB.

- **Sequence Alignment** -- Concept of local and global sequence alignment; Pairwise sequence alignment, scoring an alignment, substitution matrices, multiple sequence alignment

- **Phylogenetic Analysis** -- Basic concept of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, neighbour joining, maximum parsimony, maximum likelihood)

- **Generation and Analysis of High Throughput Sequence Data** -- Assembly pipeline for clustering of HTGS data, format of '.ace' file, quality assessment of genomic assemblies; International norms for sequence data quality; Clustering of EST sequences, concept of Unigene

- **Annotation Procedures for High Through-put Sequence Data** -- Identification of various genomic elements (protein coding genes, repeat elements); Strategies for annotation of whole genome; Functional annotation of EST clusters, gene ontology (GO) consortium, phylogenomics.

- **Structure Predictions for Nucleic Acids and Proteins** -- Approaches for prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models; Basic approaches for protein structure predictions, comparative modelling, fold recognition/ 'threading', and *ab- initio* prediction.

List of Readings:

1. **Baxevanis, A.D. and Ouellette, B.F.F.** (2005) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley and Son Inc., USA.

2. **Mount, D.W.** (2004) Bioinformatics Sequence and Genome Analysis. CSHL Press, USA.

3. **Tramontano, A.** (2007) Introduction to Bioinformatics. Chapman & Hall/CRC, USA.

4. **Zvelebil, M. and Baum, J.O.** (2008) Understanding Bioinformatics. Taylor and Francis, USA.

PMBB 0805 Practical Course

List of Practicals

- To study the growth characteristics of E. coli by turbidometry and plating methods.
- To isolate plasmid from E. coli culture (miniprep) and estimate the DNA by fluorometry.
- Induction of a protein in E. coli by IPTG and checking its expression by SDS-PAGE.
- Effect of nutrient starvation (Nitrogen, Sulphur, phosphate) on growth kinetics of bacteria.
- Demonstrate red/far-red reversibility of seed germination in *Arabidopsis* using wild-type and mutant strains.
- Demonstrate rapid induction of gene expression by auxin in coleoptile segments of dark-grown rice seedlings.
- Effect of different abiotic stresses on seed germination of wild type and mutant Arabidopsis thaliana.
- To study the effect of calcium on pollen viability and germination assay.
- To study substrate inducibility of nitrate reductase (NR) enzyme.
- Determination of optimal pH for NR activity.
- Assay of alkaline phosphatase.
- Radioactive based protein kinase assay: Effect of calcium on kinase activity using Histone, MBP, and BSA as substrate.
- Structural and functional annotation of protein coding genes from genome sequence data.
- Text based search of the NCBI database.
- Sequence alignment based search of the NCBI sequence database (BLAST).
- Analysis of the protein structure of selected protein in PDB.

- **Paper PMBB 0901.** ***STRUCTURE AND FUNCTION OF EUKARYOTIC GENOME***

- **Genomes and Comparative Genomics** -- High throughput genome sequencing; *Arabidopsis*, rice and human genomes; Centromeres and telomeres; Gene amplification; Distribution of repeat and transposable elements and their function; Genome annotation; Synteny.

- **Epigenetic Control of Gene Expression** -- Chromatin remodeling and gene activation; Inheritance of epigenetic effects.

- **Transcriptional Control of Gene Expression** -- Gene architecture; Promoter architecture; Regulatory sequences, enhancers and mechanism of their action; RNA polymerases, mediator complex and general transcription factors; Heterogeneous nuclear RNA; Cap structure and function; Polyadenylation; Britten-Davidson model; Transcription factors, DNA-binding and activation domains, activation of latent activators, co-activators.

- **Post-transcriptional Control of Gene Expression** -- Introns and exons - size, distribution and evolution; RNA splicing; Catalytic RNA; Alternative splicing; RNA stability; Small RNAs and RNA interference.

- **Functional Genomics and Proteomics** -- Approaches to analyze differential expression of genes; Gene tagging; Gene trapping; Gene silencing; Knockout mutants; Approaches to proteome analysis; Dynamic modulation of protein structure and function.

List of Readings:

1. **Grasser, K.D.** -Eds. (2006) Regulation of Transcription in Plants. Blackwell Publishing Ltd., UK.

2. **Kahl, G. and Meksem, K.** -Eds. (2008) The Handbook of Plant Functional Genomics. Wiley-VCH Verlag GmbH & Co., Germany.

3. Latchman, D.S. (2005) Gene Regulation. Taylor & Francis Group, USA.

4. **Lewin, B**. (2008) Genes IX. Jones and Bartlett Publishers, Inc., USA.

5. **Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J.** -Eds. (2000) Molecular Cell Biology. W.H. Freeman & Co., USA.

Paper PMBB 0902. ***PATTERN FORMATION AND DIFFERENTIATION IN PLANTS***

- **Developmental Differences between Animal and Plants** -- Germ line development; Regeneration and totipotency; Post embryonic development.

- **Cellular Architecture** -- Cell division cycle; Cell movements and planes of cell division; Regulation of cell size, cell shape and organ initiation.

- **Embryonic Pattern Formation** -- *Drosophila* and *Arabiodopsis.*

- **Cell Lineages and Developmental Control Genes** -- *Caenorhabditis* and Maize.

- **Plant Development and Differentiation** -- Embryogenesis; Vegetative Development - root, shoot, leaf development, trichome; Phloem differentiation.

- **Special Aspects of Plant Development** -- Sporophytic and gametopytic incompatibility; Apomixis.

- **Molecular Mechanisms for Specialized Cell Types** -- DNA Rearrangements - phase Changes, cell types in yeast, surface antigens in Trypanosomes, immunoglobulin production; Stem Cell Differentiation; DNA methylation and developmental decisions - gene silencing and genomic imprinting; Post transcriptional controls - alternative RNA splicing (sex determination in *Drosophila*), RNA editing, mRNA stability and gene expression.

List of Readings:

1. **Gilbert, S.F.** (2000) Developmental Biology. Sixth edition. INC Publishers, USA.

2. **Westhoff, P**. (1998) Molecular Plant Development: from gene to plant. The Bath Press, UK.

3. **Wolpert, L.** (2001) Principles of Development. Oxford Univ. Press, UK.

4. **Turnbill, G.N.** -Ed. (2005) Plant Architecture and its Manipulation, ARPP Rev. Vol.17, Blackwell Publ. CRC Press, USA.

Paper PMBB 0903. ***MOLECULAR BREEDING AND IPR-RELATED ISSUES***

- **Molecular Mapping** -- Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning.

- **Marker Assisted Selection (MAS)** -- Quantitative and qualitative traits; MAS for genes of agronomic importance, e.g. insect resistance, grain quality and grain yield.

- **Gene Cloning** -- Gene cloning based on mapping; Sequence-based gene cloning.

- **Intellectual Property Rights** -- Intellectual property rights (IPR); Patents, trade secrets, copyright, trademarks; Geographical Indicators (GI); Registration, subject matter and ownership of IPRs.

  Plant genetic resources; GATT & TRIPPS; Patenting of biological material; Plant breeders rights (PBRs) and farmers rights.

  Infringement, passing off action and remedies available to IPR holder.
  Some legal cases related to trademarks, copyrights and patents.

List of Readings:

1. **Ahuja, V.K.** (2007) Laws related to IPR. LexisNexis, India.

2. **Bare Act 2007** on IPR.

3. **Newbury, H.J.** -Ed. (2003) Plant Molecular Breeding, CRC Press, Blackwell Publication, UK.

4. Paterson, A.H. (1996) Genome Mapping in Plants, Academic Press, USA.

5. **de Vienne, D.** -Ed. (2003) Molecular markers in Plant Genetics, INRA Publications, France.

Paper PMBB 0904. ***PLANT BIOTECHNOLOGY***

- **Plant Tissue Culture** -- Historical perspective; Totipotency; Organogenesis, somatic embryogenesis; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis; Germplasm conservation and cryopreservation; Protoplast Culture and somatic hybridization.

- **Genetic Transformation** -- Various transformation methods; *Agrobacterium*-mediated gene delivery; T-DNA transfer; Disarming the Ti plasmid; Vector designing; Screenable and selectable markers; Chloroplast transformation.

- **Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance** -- Viral resistance; Fungal resistance; Insects and pathogens resistance; Drought, salinity, thermal stress, flooding and submergence tolerance.

- **Genetic Engineering for Quality Improvement and Other Traits** -- Post-harvest bioengineering; Concept of biofactories; Herbicide resistance; Phytoremediation; Nutraceuticals; Molecular means of heterosis breeding.

List of Readings:

1. **Bhojwani, S.S.** (1990) Plant Tissue Culture. Elsevier Science Publisher, The Netherlands.

2. **Galun, E. and Breiman, A.** (1997) Transgenic Plants. Imperial College Press, UK.

3. **George, E.F.** (1996) Plant Propagation by Tissue Culture Part 1 & Part II. Exegetics Ltd., UK.

4. **Glick, B.R. and Pasternak, J.J.** (2003) Molecular Biotechnology. ASM Press American Society for Microbiology, USA.

5. **Halford, N.** (2006) Plant Biotechnology. John Wiley & Sons Ltd., Wiley-VCH Verlag GmbH & Co., Germany.

Paper PMBB 1001: Dissertation

Dissertation work shall comprise an in-depth study pertaining to a specific research topic under the direct supervision of a faculty member. The student shall spend the entire Semester-4 in experimentation and study on the topic and shall submit the Dissertation in bound form at the end of the semester.

PMBB 0705 Practical Course

List of Practicals

- Isolate chloroplasts from the given plant material, quantitate proteins using dot blot assay, and resolve the proteins by SDS-PAGE to identify major chloroplast proteins. (JPK)

- Isolate mitochondria from the given plant material and demonstrate the activity of its marker enzyme, succinate dehydrogenase. (JPK)

- To study the effect of physical and chemical permeabilizing agents on membrane permeability.(PK)

- To isolate protoplasts from flower petals and leaves of different plants and demonstrate protoplast fusion via PEG**.** (PK)

- To learn basics of microscopy and differentiate dicot and monocot morpho- histological characteristics by using respective model systems, viz. Arabidopsis and rice. And visualization of GFP expression in transgenic Arabidopsis by using fluorescence microscope. (SK)

- Perform (i) Desalting of proteins and (ii) resolve proteins of various molecular weights (between 20 to 200 kDa) using gel filtration chromatography. (JPK)

- To extract proteins from the given plant material and estimate soluble protein content by Bradford method. (AG)

- To resolve soluble proteins by discontinuous, SDS-gel electrophoresis under denaturing conditions followed by staining with Coomassie Brilliant Blue R-250. (AG)

- To resolve soluble proteins by gradient gel electrophoresis under denaturing conditions, for optimal separation of LMW and HMW proteins followed by staining with highly-sensitive silver staining method. (AG)

- To isolate native proteins for resolving isozymes using native, non- denaturing polyacrylamide gel electrophoresis. (AG)

- To prepare electrocompetent cells of E. coli and transform them by plasmid using electroporator. (IDG)

- To isolate plant DNA from different sources and perform Southern hybridization after digestion with restriction enzymes. (SK)

- To clone a DNA fragment in plasmid vector by ligation, transformation of ligation mix in *E. coli* cells and selection of transformants. (SKA)
- To perform ‘Colony PCR’ to screen for the positive *E. coli* transformants containing the ligated product and perform restriction digestion of the positive clone. (SKA)

- To prepare yeast competent cells and transform yeast cells with plasmid DNA. (SKA)

PMBB 0805 Practical Course

List of Practicals

- To perform amplification of cDNA by PCR and to perform 3'-RACE (Rapid amplification of cDNA ends). (GP)
- To study the growth characteristics of E. coli by turbidometry and plating methods. (IDG)
- To isolate plasmid from E. coli culture (miniprep) and estimate the DNA by fluorometry. (IDG)
- Induction of a protein in E. coli by IPTG and checking its expression by SDS-PAGE. (IDG)
- Effect of nutrient starvation (Nitrogen, Sulphur, phosphate) on growth kinetics of bacteria. (GP)
- Demonstrate red/far-red reversibility of seed germination in *Arabidopsis* using wild-type and mutant strains. (JPK)
- Demonstrate rapid induction of gene expression by auxin in coleoptile segments of dark-grown rice seedlings. (JPK)
- Effect of different abiotic stresses on seed germination of wild type and mutant Arabidopsis thaliana. (GP)
- To study the effect of calcium on pollen viability and germination assay. (GP)
- To study substrate inducibility of nitrate reductase (NR) enzyme. (AKS)
- Determination of optimal pH for NR activity. (AKS)
- Assay of alkaline phosphatase. (AKS)
- Radioactive based protein kinase assay: Effect of calcium on kinase activity using Histone, MBP, and BSA as substrate. (GP)
- Text based search of the NCBI database. (SR)
- Sequence alignment based search of the NCBI sequence database (BLAST). (SR)
- Analysis of the protein structure of selected protein in PDB. (SR)

PMBB 0905 Practical Course

List of Practicals

- Structural and functional annotation of protein coding genes from genome sequence data. (SR)
- To isolate RNA from a given plant material and to perform the qualitative analysis by formaldehyde agarose gel electrophoresis. (SK)
- Perform real-time PCR analysis to quantify the expression of a particular gene. (SK)
- Assembly and analysis of genome sequence data.
- To confirm T-DNA insertion in an *Arabidopsis* mutant (M3 population) and identify heterozygous and homozygous plants for insertion using PCR method. (SKA)
- To resolve and visualize low molecular weight RNAs by denaturing urea-PAGE electrophoresis. (SKA)
- To study organogenesis and differentiation of shoots and roots from various explants. (PK)
- To study adventive somatic embryogenesis in higher plants. (PK)
- To study cytosine methylation and restriction protection of DNA.
- To study differences in cytosine methylation at genomic level by methylation dependant PCR.
- To isolate genomic DNA from two species of Poaceae and perform RFLP analysis. (MM)
- To perform RAPD analysis of two varieties of *Brassica juncea*. (MM)
- To detect polymorphism between two varieties of *Brassica juncea* using SSR markers. (MM)
- To demonstrate Agrobacterium-mediated gene delivery and study the expression of gus gene by histochemical and fluorimetric methods. (PK)
- To analyze the transgenic plant for the expression of foreign protein by Western blotting method.
- Detection of viral DNA accumulation in plants using Southern analysis and DIG-labelled probes. (IDG)
- Intracellular protein localization by transient expression of protein: GUS/GFP Fusion constructs in onion peel cells assays by particle gun bombardment. (SK)