

DEPARTMENT OF BOTANY
NORTH-EASTERN HILL UNIVERSITY, SHILLONG- 793022
M. Sc. (Plant Molecular Biology)
SYLLABUS, 2017
CHOICE BASED CREDIT SYSTEM (CBCS)

The M.Sc. (Plant Molecular Biology) programme under the Department of Botany of the University comprises of four semesters spread over a period of two years. Students would be required to earn 72 credits for the award of M.Sc. (Plant Molecular Biology) degree. The course shall have a minimum of 60 credits by way of core courses offered by the Department and 12 credits by way of open courses offered by the Department/other Departments of the University. Each semester shall comprise of theory papers of 4 credits (100 marks) each and lab work/ practical paper of 2-6 credits (150 marks) each. Students shall be evaluated by way of continuous assessment comprising 25% of credit value and end semester examination comprising 75% of credit value. In addition to this, as part of core curriculum, students will be required to undertake project work in the IIIrd and IVth semesters and submit a dissertation at the end of IVth semester encompassing the project work carried out by the student. The project shall carry 12 credits.

Course Code	Course Title	Credit	Max. Marks
Semester – I			
PMB (C) 101	Microbiology	4	100
PMB (C) 102	Cell Biology and Plant Physiology	4	100
PMB (C) 103	Fundamentals of Genetic engineering	4	100
PMB© 104	Lab work/Practical	6	150
		18	450
Semester –II			
PMB (C) 201	Plant Biochemistry and Molecular Biology	4	100
PMB (C) 202	Eukaryotic Genome Organization	4	100
PMB (O) 203	Stress Biology	2	50
PMB (O) 204	Bioprocess Development	2	50
PMB (O) 205	Techniques in Molecular Biology	2	50
PMB © 206	Lab work/Practical	4	100
		18	450
Semester –III			
PMB (C) 301	Genetics, Cytogenetics and Plant Breeding	4	100
PMB (O) 302	Metabolite Engineering	2	50
PMB (O) 303	Environmental Pollution and Conservation	2	50
PMB (O) 304	Computer Applications and Bioinformatics	2	50
PMB © 305	Lab work/Practical	2	50
		12	300
PMB (C) 306/405*	Project work and Dissertation*		

*Continues into Semester IV and shall be evaluated at the end of IVth Semester

Semester –IV

PMB (C) 401	Plant Biotechnology	4	100
PMB (C) 402	Molecular Basis of Differentiation	4	100
PMB © 403	Lab work/Practical	4	100
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		12	300
PMB (C) 306/404*	Project work and Dissertation	12	300

(*Continued from Semester III)

Total credits for the course:

72 **1800**
(Core: 60 and Open: 12)

Broad areas for specialization through Project Work

- Microbiology
- Molecular Ecology
- Plant Biotechnology
- Plant Molecular Biology

PMB (C) 101: Microbiology [Theory (4 Credits)]

Unit I Soil microorganisms: types, methods of isolation and factors affecting their growth; Ultra structures and characteristics of bacteria and plant viruses; Importance and application of microbes in genetic engineering and biotechnology. Bio-fertilizers: types and mass production. Plant growth promoting microbes (PGPM) and their mass production in agriculture and forestry.

Unit II Symptomology and identification of plant diseases with reference to fungi, bacteria and viruses; Water borne pathogens and important diseases caused by them; Mycoplasma and important diseases caused by them. Biological control of plant diseases.

Unit III Various Measurement of microbial growth; Effect of environmental factors on microbial growth; Microbial cultures: Methods of isolation and maintenance of pure cultures. Biopesticides: introduction, types of microbial species as fungal and bacterial insecticides.

Unit IV Microbes in industrial production of alcohol, organic acids and antibiotics; Microbial degradation of petroleum and xenobiotics; Water purifications; Mycotoxins– harmful effects.

Suggested readings:

- Agrios, G.N. (2008). Plant Pathology (5th edition). Academic Press, Reed Elsevier India Private Ltd., New Delhi, India.
- Blakeman, J.P and Williamson, B. (1994). Ecology of Plant Pathogens. CAB International.UK.
- Dubey, R.C. and Maheshwari, D.K. (1999). A text book of Microbiology, S. Chand & Company Ltd., New Delhi, India.
- Eugene, L.M. (2008). Environmental Microbiology- from genome to biogeochemistry. Blackwell Publishing Australia, Australia.
- Jeffery, C.P. (2014). Fundamental of Microbiology. 10th edition. Jones and Bartlett Publishers Learning. USA.
- Madigan, M.T., Martinko, J.M and Parker, J. (2006). Brock Biology of Microorganisms, 11th Edition. Prentice Hall International, Inc. USA.
- Mehrotra, R.S. (1995). Plant Pathology. Tata Mc Graw Hill, New Delhi, India.
- Mehrotra, R.S. and Aggarwal, A. (2003). Plant Pathology. 2nd edition. Tata Mc Graw Hill. New Delhi, India.
- Prescot, L.M., Harley, J.P. and Klein, D.A. (2005). Microbiology. 6th Edition Mc Graw – Hill International Edition. USA.
- Singh, R.P. (2012). Plant Pathology. Second edition. Kalyani Publishers, New Delhi, India.
- Tate, R.L. (2000). Soil Microbiology. 2nd edition. John Wiley and Sons, Inc. New York. USA.
- Tortora, G.J., Funke, B.R. and Case, C.L. (2008). Microbiology– An Introduction. 9th edition. Dorling Kindersley (India), New Delhi, India.
- Van Elsas, J.D., Trevors, J.T. and Wellington, E.M.H. (1997). Modern Soil Microbiology, Marcel Dekker Inc. USA.
- Willey, J.M., Sherwood, L.M. and Woodverton, C.J. (2011). Prescott's Microbiology. 8th edition. Mc Graw Hill. New York, USA.
- Wulf, C. and Anneliese, C. (2000). Biotechnology: A textbook of industrial microbiology. Panima Publishing Corporation, New Delhi, India.
- Webster, J. (1980). An introduction to fungi. Cambridge University Press, UK.
- Webster, J. and Weber, R.W.S. (2007). Introduction to fungi. Cambridge University Press, UK.

PMB (C) 102: Cell Biology and Plant Physiology (4 Credits)

- Unit I Plasma membrane: structure and functions; Membrane transport: ion channels and pumps; Mitochondria: structure, and organization of respiratory chain complexes; Chloroplast: organization of photosynthetic complexes; Cell cycle: phases and their regulation.
- Unit II Bioenergetic pathways: Mechanism of photoexcitation of chlorophyll and electron transport chain; Carbon fixation pathways in photosynthesis; Regulation of photosynthetic activity; Glycolysis and its regulation; Mechanism of oxidative decarboxylation of pyruvic acid; TCA cycle and its regulation; Fatty acid oxidation; Electron transport and oxidative phosphorylation; Biological nitrogen fixation and assimilation of ammonia; Gluconeogenesis.
- Unit III Plant Growth Regulators: Structure and metabolism of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, salicylic acid, jasmonates; Molecular mechanism of hormone Action: hormone signal perception, transduction and gene regulation; Essential nutrients, deficiencies and plant disorders; Chelates, Heavy-metal stress and homeostasis.
- Unit IV Photoperiodism: Photoperiodic responses, critical day length, site of perception of photoperiod; Senescence; Dormancy: types and mechanism of regulation, Responses of plants to environmental stress; Stress induced gene expression and signaling.

Suggested readings

- Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)
- Bernle, J. D. and Black M. (1992). Seed physiology and biochemistry. Springer-Verlag.
- Buchanan, B.B., Wilhelm G. and Russel J. (2003). Biochemistry and molecular biology of plants. ASPB. US.
- Dennis, D. T. (1997). Plant metabolism. John Wiley.
- Dey, P. M. and Harborne, J. B. (2000). Plant biochemistry. Academic Press .
- Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
- Gilmartin, P.M. and Bowler, C. (2015). Molecular Plant Biology vol 1 and 2 Oxford Univ. Press.
- Goodwin, T. W. and Mercer E. I. (1983). Introduction to plant biochemistry. Pergamon Press.
- Gresshoff, P. M. (2000). Plant biochemistry. John Wiley.
- Harvey, L., Berk, A., Kaiser, C.A., Krieger, M., Scott, M. P. and Bretscher, A. (2007). Molecular cell biology. 6th edition. W. H. Freeman.
- Helgi Öpik and Stephen A. Rolfe (2005). The physiology of flowering plants - 4th edition CUP
- Hopkins, W.G. and Hunter N.P. (2003). Introduction to plant physiology. John Wiley & Sons.
- Krauss, G. (1999) Biochemistry of signal transduction & regulation. John Wiley.
- Laurence, V., Gareth Hughes, M. and van den Bosch, F. (2007). The study of plant disease Epidemics APS Press.
- Lender, D. W. (2001). Photosynthesis. Marcel Dekker.
- Leopold, A. C. and Kreidman P. E. (1980). Plant growth and development. Tata MacGraw Hill.
- Lincoln, T. and Zeiger, E. (2002). Plant physiology. Palgrave Macmillan.
- Nelson, D.L. and Cox, M.M. (2013). Lehninger Principles of Biochemistry. 6th Edition, Freeman and Company, New York.

- Rao, K.V. M., Raghavendra, A.S. and Reddy, J. K. (2006). Physiology and molecular biology of stress tolerance in plants. Springer.
- Sachs, J. and Ward, H. M. (2015). Lectures on the Physiology of Plants. Arkose Press
- Scott P. (2008). Physiology and behaviour of plants. Wiley-Blackwell.
- Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A. (2014). Plant Physiology and Development, Sinauer Associates.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2004). Molecular biology of the gene. Pearson.

PMB (C) 103: Fundamentals of genetic engineering (4 Credits)

- Unit I General introduction and concept; DNA modifying enzymes and restriction enzymes; Cloning strategies: Genomic libraries, cDNA libraries, single gene cloning; Biosafety guidelines.
- Unit II Recombinant DNA technology: Restriction enzymes; Gene cloning: Cloning vehicles (plasmids, bacteriophages, YAC, BAC); Construction and screening of genomic DNA and cDNA libraries; Selectable markers; Reporter genes; Promoters; Methods for transferring recombinant DNA to host cells.
- Unit III Screening and selection for transformants: Hybridizations- Colony, Southern, Northern, Western, DNA sequencing techniques including automated DNA sequencing; TILLING (Targeting Induced Local Lesions in Genomes).
- Unit IV Applications of transgenesis: Disease, pest and herbicide tolerance, Improvement of crop quality, Abiotic stress tolerance, Molecular Pharming; Transgene stability; Gene silencing; IPRs.

Suggested readings

- Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2014). Molecular Biology of the Cell. 6th edition. Garland Science.
- Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)
- Buchanan, B. B., Gruissem, W., Russell, L. J. (2015). Biochemistry and Molecular Biology of Plants, 2nd Edition Wiley Intl.
- Gilmartin, P.M. and Bowler, C. (2015). Molecular Plant Biology Vol 1 and 2. Oxford Univ. Press
- Grotewold, E. and Chappell, J. (2015). Plant Genes, Genomes and Genetics. Wiley Blackwell.

PMB © 104 (Lab work/Practicals) (6 Credits)

Singh, R. P., Passos, L.P. and Magalhaes, J.R. (2005). Focus on plant molecular biology –I: nitric oxide signaling in higher plants. Studium Press, Houston, USA.

Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.

1. Preparation of media for growth of various microorganisms.
2. Isolation, identification and enumeration of various microorganisms from soil, air and water.
3. Calibration of microscope and measurement of dimension of microbial cells.
4. Preparation, preservation and maintenance of microbial pure cultures.
5. Preparation of competent cells.
6. Determination of water potential in plant tissues.
7. Estimation of chlorophyll a, b and total chlorophyll content of plant tissues.
8. Isolation of subcellular organelles by differential centrifugation.
9. Isolation of plant pigments and measurement of hill reaction activity.
10. Isolation of plasmid DNA: i) minipreparation ii) megaprep.
11. Isolation of genomic DNA.
12. Restriction digestion and restriction map analysis.
13. PCR.
14. Transformation of *E.coli* with plasmids, calculation of transformation efficiency.

Suggested readings

Grotewold, E. and Chappell, J. (2015). Plant Genes, Genomes and Genetics. Wiley Blackwell.

Hopkins, W.G. and Hunter N.P. (2003). Introduction to plant physiology. John Wiley & Sons.

Madsen, E. L., (2008). Environmental Microbiology- from genome to biogeochemistry. Blackwell Publishing Australia.

Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.

PMB (C) 201: Plant Biochemistry and Molecular Biology (4 Credits)

- Unit- I Macromolecular Structure: Carbohydrates, Lipids, Phospholipids; Role of phospholipids in signal transduction in cells; Amino acids: structure and properties; Proteins: Peptides and covalent structure of proteins protein folding and sub-unit assembly; Macromolecular interactions: Protein – Protein, Protein – Nucleic acids.
- Unit- II Enzymes: structure of active site, mechanisms of action, kinetics of enzyme catalysed reactions; Enzyme inhibition; Regulation of enzyme activity; Allosteric interactions; Industrial applications of enzymes; Principles of immobilized enzyme technology; Post translational modification of enzymes.
- Unit- III Structure of nucleic acids: DNA double helix and its conformations, DNA triple and quadruple helices, t-RNA, r-RNAs; DNA replication: Machinery and mechanism in prokaryotes and eukaryotes; RNA transcription: Machinery and mechanism in prokaryotes and eukaryotes; RNA processing: processing of tRNA and hnRNA; RNA editing; Genetic code and exceptions to its universality.
- Unit- IV Translation: Machinery and mechanism (tRNA charging, initiation in prokaryotes and eukaryotes, elongation and termination); Regulation of gene expression: Regulation at the levels of chromatin organization, DNA amplification, initiation of transcription, attenuation, anti-sense RNA, alternate promoters, RNA processing, mRNA degradation and translation.

Suggested readings

- Berg, J.M., Tymoczko, J.L. and Stryer, L., (2002) Biochemistry (5th edition) W.H. Freeman & Co.
- Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
- Bowsher C., Martin, S., Tobin, A. (2008). Plant Biochemistry, Taylor & Francis.
- Clark, D. (2005). Molecular Biology. Elsevier publishers.
- Conn, E.E. and Stumpf, P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
- Dennis, D.T. (1998). Plant metabolism. Longman.
- Dey, P.M. and Harborne J.B. (1997). Plant Biochemistry. Acad. Press.
- Eisenthal, R. and Danson, M.J. (2006). Enzyme assays. Oxford University Press.
- Freifelder, D. (2001). Essentials of Molecular Biology. Narosa Publishing House.
- Ganesh, A. (2008) Plant Proteomics, John Wiley.
- Heldt, H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
- Horton, H. R., Moran, L.A., Scrimgeour, K.G., Perry, M. D. and Rawn, J. D. (2006). Principles of Biochemistry (4th edition). Pearson-Prentice Hall.
- Kukol, A. (2008). Methods in molecular biology: Molecular modelling of proteins. Humana Press.
- Lewin, B. (2004). Genes VIII Pearson-Prentice Hall,
- Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). Biochemistry. 3rd edition. Pearson.
- Mikkelsen, S. R. and Eduardo, C. (2004). Bioanalytical Chemistry. Wiley-Interscience.
- Nelson, D. L. and Cox, M. M. (2013). Lehninger, Principles of Biochemistry (6th edition) Freeman & Co., New York.
- Voet D., Voet, J.G. and Pratt, C. W. (2006). Fundamentals of Biochemistry (2nd edition) by John Wiley and Sons
- Voet, D. J., Voet, J.G. Pratt, C.W. (2008). Principles of Biochemistry John Wiley Inc.
- Walker J.M. and Rapley R.. (2002). Molecular Biology and Biotechnology. Panima, New Delhi.

PMB (C) 202: Eukaryotic Genome Organization (4 Credits)

- Unit I Eukaryotic Genome Organization: Law of constancy and C value paradox, Repetitive and non-repetitive DNA; DNA mapping; Eukaryotic DNA Packaging; Genome organization of mitochondria and chloroplasts.
- Unit II Chromosome Structure: Changes in chromosomes with reference to centromeres and telomeres; Exons and introns: Size, distribution and evolution, Organization of interrupted genes, Transposons and Retroposons; Split genes; RNA splicing; Catalytic RNA; Small interfering RNAs (siRNAs); Molecular mapping: RFLP, AFLP, SNP, RAPD markers; Construction of genetic maps; QTL mapping.
- Unit III Regulation of transcription and translation process in eukaryotes: Control elements associated with eukaryotic genes; Enhancers and silencers; HLH, Leucine zipper proteins; Noncoding RNAs; mRNA stability; 5' and 3' UTRs; mRNA localization.
- Unit IV DNA damage, repair and recombination: Different types of DNA damages; Variety of DNA repair systems in eukaryotes: Base excision repair system, Nucleotide excision repair system, Mismatch repair system, Recombination repair system; Recombination: Homologous and non-homologous recombination.

Suggested readings

- Brown, T. A. (2006). Essential Molecular Biology: Practical approach Vol I & II. Oxford.
- Brown, T. A. (2006). Genomes 3, Taylor & Francis.
- Clark, D. (2005). Molecular Biology. Elsevier publishers.
- Clark, D. A. (2005). Molecular biology: Understanding the Genetic Revolution. Academic Press.
- Cooper, G. M. and Hausman, R. E. (2006). The Cell, Macmillian.
- Freifelder, D. (2001). Essentials of Molecular Biology. Narosa Publishing House, New Delhi.
- Grasser, K. (2007). Regulation of transcription in Plants. Blackwell.
- Hartwell, L. H., Hood, L., Goldberg, M. L., Reynolds, A.E., Silver, L. M. & Veres, R. C. (2004). Genetics from Genes to Genomes McGraw-Hill.
- Leister, D. (2006). Plant Functional Genomics. Panima Publishing Corp. Delhi.
- Lewin, B. (2004). Genes VIII. Pearson-Prentice Hall.
- Malacinski, G. M. (2002). Essentials of Molecular Biology. Fourth Edition. Jones & Bartlett Publishers.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.

PMB (O) 203: Stress Biology (2 Credits)

Unit-I Essential nutrients, deficiencies and plant disorders; Chelates; Treating nutritional deficiencies; Heavy-metal stress and homeostasis; Molecular mechanism of mineral nutrition in plants.

Unit-II Stress: Osmotic, temperature, salinity, anaerobic and oxidative; Responses of plants to environmental stress; Oxidative burst; Stress induced gene expression and signaling.

Suggested readings

- Aducci P. (1997). Signal Transduction in Plants. Birkhauser Verlag.
- Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)
- Bernle J. D. and Black M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.
- Buchanan B.B., Wilhelm G. and Russel J. (2003). Biochemistry and Molecular Biology of Plants. ASPB. US.
- Dennis D. T. (1997). Plant Metabolism. John Wiley.
- Dey P. M. and Harborne, J. B. (2000) Plant Biochemistry. Academic Press .
- Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
- Goodwin T. W. and Mercer E. I. (1983). Introduction to Plant Biochemistry. Pergamon Press.
- Gresshoff P. M. (2000). Plant Biochemistry. John Wiley.
- Hopkins W.G. and Hunter N.P. (2003). Introduction to Plant Physiology. John Wiley & Sons.
- Krauss G. (1999) Biochemistry of Signal Transduction & Regulation. John Wiley.
- Lehninger A. L. (1993). Principle of Biochemistry. CBS.
- Lender D. W. (2001). Photosynthesis. MerceL Decker.
- Leopold A. C. and Kreidman P. E. (1980). Plant growth and development. Tata MacGraw Hill.
- Lincoln T. and Zeiger E. (2002). Plant Physiology. Palgrave Macmillian.
- Mattoo A. K. and Shuttle, J. C. (1995). The Plant hormone Ethylene. CRC. Press.
- Mukherji S. and Ghosh A. K. (1996). Plant Physiology. Tata- McGraw Hill.
- Noggle G. R. and Fritz C. J (1989). Introductory Plant Physiology. Prentice Hall
- Seigler D. S. (1994). Plant secondary metabolism. Narosa
- Srivastava H. S. (1994). Plant Physiology. Rastogi and Co.
- Thomas B. and Vince-Prue D. (1997). Photoperiodism in plants. Academic Press.

PMB (O) 204: Bioprocess Development (2 Credits)

Unit I Plant growth promoting microbes (PGPM) and their mass production for agriculture and forestry; principles and usage of bioreactors; types of bioreactors; microbial fermentation.

Unit II Environmental monitoring of GEMs; bioconversion of waste products by microbes with special reference to biogas and organic compost; steroid bio-transformations.

Suggested readings

- Alexander, N.G. and Hiroshi, N. (1998). Microbial Biotechnology. W.H.Freeman & Co., USA.
- Crueger, W. and Crueger, A. (2000). Biotechnology: A textbook of industrial microbiology. Panima Publishing Corporation, India.
Dorling Kindersley (India), New Delhi, India.
- Edward, A.B. (1992). Modern Microbiology – principles and application, WMC Brown Publishers, USA.
- Flickinger, M.C. and Drew, S.W. (1999). Encyclopedia of bioprocess technology. Vol 1-5. John Wiley & Sons, Inc.
- Mansi, E.M.T.E.L. and Bryle, C.F.A. (2002). Fermentation Microbiology and Biotechnology Taylor & Francis Ltd, UK.
- Stanbury, P.F., Whitaker, A. and Hall, S.J. (1997). Principles of Fermentation Technology, Pergamon Press, Oxford.
- Tortora, G.J., Funke, B.R. and Case. C.L (2008). Microbiology– An Introduction. 9th edition.
- Young, M.M. (2004). Comprehensive Biotechnology. The principles, applications and regulations of biotechnology in industry, agriculture and medicine, Vol 1, 2, 3 and 4 Reed Elsevier India Private Ltd, India.

PMB (O) 205: Techniques in Molecular Biology (2 Credits)

Unit I Microscopy: fluorescence, confocal, fluorescence resonance energy transfer (FRET), and atomic-force microscopy (AFM/SFM); spectrophotometry; chromatography: gel filtration, adsorption and ion exchange; protein digestion and profiling.

Unit II Electrophoresis; blotting: southern, western, northern, south-western, nucleotide sequencing and analysis; gene reporter assays.

Suggested readings

- Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
- Boyer, R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
- Brown, T.A. (1989). Genetics a molecular approach. Van Nostrand.
- Conn, E.E. and Stumpf P.K. (1994). Outlines of biochemistry. Wiley Eastern.
- Dennis, D.T. (1998). Plant metabolism. Longman.
- Dey, P.M. and Harborne, J.B. (1997). Plant biochemistry. Acad. Press.
- Heldt, H. (1997). Plant biochemistry and molecular biology. Oxford Univ. Press.
- Lea, P.J. and Leagood, R.C. (1999). Plant biochemistry and molecular biology. Wiley.
- Lewin, B. (2002). Genes VIII. Oxford.
- Nelson, D.L. and Cox, M.M. (2000). Lehninger principles of biochemistry. Macmillan Worth.
- Plumer, D.T. (1993). An introduction to practicals in biochemistry. Tata McGraw Hill.
- Sinden, P.R.R. (1994). DNA structure and function. Acad. Press.
- Stryer, L. (1993). Biochemistry. W.H. Freeman.
- Walker, J.M. and Rapley, R. (2002). Molecular biology and biotechnology. Panima.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.
- Zubay, G. (1993). Biochemistry. W.C. Brown.

PMB © 206: Lab work/ Practicals (4 Credits)

1. Preparation of standard curves for starch, amino acids and soluble proteins.
2. Protein purification by
 - Ammonium Sulfate precipitation.
 - Gel Filtration.
 - Gel electrophoresis.
3. Assay of enzyme activity and determination of K_m , V_{max} and K_{cat} .
4. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps and agarose gel electrophoresis of DNA.
5. Nuclear DNA isolation.
6. Determination of T_m value of isolated DNA.
7. Restriction digestion of plasmid and nuclear DNA.
8. Cloning of genomic DNA in standard plasmid vectors.
9. Confirmation of the insert, Miniprep of recombinant plasmid DNA.
10. Southern blotting; preparation of DNA probes.
11. Polymerase chain reaction based amplification of plant genes.
12. Basic Aspects of Genome Annotation.
13. Prediction of genes and gene structures (gene modeling) using online (web) servers.
14. Prediction of ORFs and Genes; Signal sequences (Promoters, Primers, splice sites, UTRs etc.).

Suggested readings

- Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
- Boyer R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
- Brown, T.A. (1989). Genetics a molecular approach. Van Nostrand.
- Heldt H. (1997). Plant biochemistry and molecular biology. Oxford Univ. Press.
- Lea P.J. and Leagood R.C. (1999). Plant biochemistry and molecular biology. Wiley.
- Lewin B. (2002). Genes VIII. Oxford.
- Lodish H. *et al.* (1996). Molecular cell biology. Sc. American Books.
- Sinden P.R.R. (1994). DNA structure and function. Acad. Press.
- Stryer, L. (1993). Biochemistry. W.H. Freeman.
- Walker J.M. and Rapley R. (2002). Molecular biology and biotechnology. Panima.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.

PMB(C) 301: Genetics, Cytogenetics and Plant Breeding (4 Credits)

- Unit I Modern gene concept: genetic fine structure, cis-trans test; Eukaryotic gene organization, introns and exons; Organization of eukaryotic chromosomes; Linkage and genetic recombination, linkage groups; Mutations: induced and spontaneous; Physical and chemical mutagens; DNA damage and repair; Molecular mechanism of mutation and recombination.
- Unit II Chromosomal aberrations in plants: origin and meiotic & breeding behaviours of structural aberrations; Breeding behaviour of interchange heterozygotes and permanent hybrids; Interchange tester sets; Euploidy and aneuploidy; Origin and meiotic & breeding behaviours of monosomics and primary trisomics; Monosomic analysis.
- Unit III Origin and meiotic & breeding behaviours of haploids, autopolyploids and allopolyploids; Genome constitution and analysis; Genome and Chromosome engineering: Synthesis of tetraploid, hexaploid and octoploid triticales; Alien chromosome additions and substitutions; Chromosome fragment transfers and crop improvement; Giemsa banding of chromosomes; FISH.
- Unit IV Phenotypic variance and its components; Heritability of traits and its estimation; Gene frequency in a population, genetic equilibrium and Hardy-Weinberg law, barriers to gene flow and mechanism of speciation; Heterosis and hybrid vigour; Concept of combining ability; Male sterility and its application in hybrid seed production.

Suggested readings

- Allard R. W. (1960). Principles of plant breeding. John Wiley.
- Ayala F. J. and Kiger J. A. (1980). Modern genetics. Benjamin Cummings.
- Brown T. A. (1989). Genetics- a molecular approach. Chapman & Hall.
- Brown T. A. (1999). Genomes. John Wiley & Sons.
- Chopra V. L. (1989). Plant breeding. Oxford & IBH.
- Clark M. S. and Wall W. J. (1996). Chromosomes. Chapman & Hall.
- Elrod S. and Stansfield W. (2004). Genetics. Tata McGraw-Hill.
- Fukui K. and Nakayam S. (1996). Plant chromosomes: Laboratory methods. CRC Press.
- Griffiths A.J. F. et al. (2000). An introduction to genetic analysis. W. H. Freeman.
- Gupta P. K. (1995). Cytogenetics. Rastogi & Co.
- Gupta P. K. (1998). Genetics and biotechnology in crop improvement. Rastogi & Co.
- Hartl D. L. (1991). Basic genetics. Jones & Bartlett.
- Hartl D. L. and Jones E. W. (2001). Genetics-analysis of genes & genomes. Jones and Bartlett.
- Jain H. K. (1999). Genetics. Oxford-IBH.
- Poehlman J. M. and Sleper D. A. (1995). Breeding field crops. Iowa State University Press.
- Sharma A. K. and Sharma A. (1999). Plant chromosomes: Analysis, manipulation and engineering. Harwood Academic Publishers.
- Sharma J. R. (1994). Principles and practices of plant breeding. Tata-McGraw Hill.
- Simmonds N. W. (1979). Principles of crop improvement. Longman.
- Snustad D. P. and Simmons M. J. (2000). Principles of genetics. John Wiley and Sons.
- Stansfield W. D. (1969). Theory and problems of genetics. McGraw-Hill.
- Strickberger M. W. (1985). Genetics. Macmillan.
- Sybenga J. (1972). General cytogenetics. North Holland.
- Tamarin R. H. (2002). Principles of genetics. Tata McGraw-Hill.

PMB (O) 302: Metabolite Engineering (2 Credits)

- Unit I The concept of secondary metabolites; Importance of secondary metabolites in medicine and agriculture; Flavanoid biosynthetic pathways and their regulation. Intermediate pools and their significance.
- Unit II Principles of Biochemical Engineering, Metabolic flux analysis; Enzyme engineering for increased secondary metabolite production. Inverse metabolic engineering; Transcriptome profiling.

Suggested readings

- Cortassa, S., Aon, M. A., Iglesias, A. A., Lloyd, D. (2007) An introduction to metabolic and cellular engineering. World Scientific.
- Crozier, A. (2006) Plant secondary metabolites: occurrence, structure and role in the human diet Springer, New York.
- Eisenthal, R. and Danson, M.J. (2006). Enzyme assays. Oxford University Press
- Horton, H. R., Moran, L.A., Scrimgeour, K.G., Perry, M. D. and Rawn, J. D. (2006). Principles of biochemistry (4th edition) Pearson-Prentice Hall.
- Nelson J. (2001). Advances in biochemical engineering and biotechnology. Springer.
- Sang Yup Lee and Papoutsakis, S.K. (2006). Metabolic engineering. Marcel Dekker Inc. N.Y
- Stephanopoulos, G. N., Aristidou, A. A. and Nielsen, J. (2000). Metabolic engineering: principles and methodologies. Academic Press.
- Verpoorte, R. (2008). Metabolic engineering as a strategy to improve the production of secondary metabolites in plants or plant cell cultures, ISHS, Sweden
- Verpoorte, R.; Alfermann, A.W.; Johnson, T.S. (2008). Applications of plant metabolic engineering, Springer.
- Verpoorte, R. and Alfermann, A.W. (2008). Metabolic engineering of plant secondary metabolism, Springer, N.Y.

PMB (O) 303: Environmental Pollution and Conservation (2 Credits)

Unit I Environmental pollution: Sources of air, soil and water pollution, Parameters to assess the pollution level, effects of pollution on plants and ecosystems and pollution abatement; Global environmental change: Climate change: Greenhouse gases (CO₂, CH₄, N₂O, CFCs: sources, trends and role), Consequences of climate change, Ozone depletion.

Unit II Human impacts on forest ecosystems; soil erosion and its control; shifting cultivation and its ecological implications; coal mining problem of northeast India; eco-restoration of degraded ecosystems; environmental impact assessment (EIA).

Suggested readings

Cain, M.L., Bowman, W.D. and Hacker, S.D. (2014). Ecology. Third Edition. Companion Website.

Cunningham, W.P. and Saigo, B.W. (1999). Environmental Science. WCB, McGraw Hill.

Hunter, M.L. (1996). Fundamentals of Conservation Biology. Blackwell Science, Oxford.

Johnson, E.A. and Miyanishi, K. (2007). Plant Disturbance Ecology: the process and the response.

Jones, A.M. (1997). Environmental Biology. Routledge Publications, London and New York.

Mooney, H.A. and Gordon, M. (1983). Disturbance and Ecosystems components of Response. Springer Verlag. Berlin Heidelberg, New York, Tokyo.

Primack, R.B. (2014). Essentials of Conservation Biology. Sixth Edition. Sinauer Associates, Inc. Sunderland, Massachusetts, USA.

PMB (O) 304: Computer Applications and Bioinformatics (2 Credits)

Unit I Applications of computers in Biology; Computation of variation; hypothesis testing(“t” test, “z” test); analysis of variance, random variables, frequency distributions; ordinary least square fitting. Overview of available Bioinformatics resources on the web.

Unit II Sequence alignment algorithms: Needleman & Wunsch/ Smith & waterman, PRAS, CLUSTALW: Scoring matrices: MDM/ BLOSUM /CSW; Database designing, data capturing :Data Abstraction, Data Models, Instances & Schemes; Structured Query Language; Database Similarity Searches: BLAST, Nearest neighbour search, FASTA; Phylogenetic Analysis Tools: Maximum Likelihood, Parsimony methods, Distance methods, Model Comparison; Structure prediction tools and homology modeling.

Suggested readings

- Attwood, T. K. and Parry-Smith, D. J. (2005). Introduction to bioinformatics, Pearson.
- Baxevanis, A.D., Davison, D.B., Page, R. D. M. and Petsko, G.A. (2004). Current protocols in bioinformatics, John Wiley & Sons Inc.
- Bourne, P. E. and Weissig, H. (2003). Structural bioinformatics: Methods of biochemical analysis V. 44. Wiley-Liss.
- Dunn, M. J. (2002). Proteomics: from protein sequence to function by Pennington,.Viva Books Private Ltd.
- Hans D. and Didier R. (2003). Molecular modeling: Basic principles and application Wiley VeH Gmbh and Co. KGA.
- Hecker, M. and Mullner, S. (2003). Proteomics of microorganisms Springer-Verlag.
- Isaev A. (2004). Introduction to mathematical methods in bioinformatics Berlin Springer.
- Krane, D. E., Raymer, M. L. (2003). Fundamental concepts of bioinformatics. Pearson edu.
- Kukol, A (2008). Molecular modeling of proteins, Humana Press, Totowa, NJ 2008
- Liebler, D.C. and Yates, J.R. III (2002). Introduction to proteomics: tools for the new biology. Humana Press, New York.
- Mount, David (2004). Bioinformatics: Sequence and genome analysis, Cold Spring Harbor Laboratory Press.
- Raman, K. V. and Pal, S. (2005). Mathematics in chemistry, Vikas publishing house Pvt. Ltd.
- Sankoff, D.and Nadeau, J.H. (2000). Comparative genomics: empirical and analytical approaches to gene order dynamics, map alignment and the evolution of gene families, Kluwer Academic Publishers.

PMB(C) 305: Lab work/ Practicals (2 Credits)

1. Preparation of materials and study of somatic chromosomes of some common plants.
2. Collection of flower buds and study of meiosis of some common plants.
3. Study of meiosis of some aberrant plants.
4. Numerical exercises on linkage and crossing over.
5. Numerical exercises on χ^2 for independence of attributes and goodness of fit.
6. Giemsa bonding of chromosomes.
7. Isolation of RNA.
8. cDNA synthesis and cloning.
9. PCR/ RT-PCR technique.
10. Sequencing and computer analysis.
11. Restriction mapping.
12. Isolation of organelle DNA.

Suggested Readings

- Brown T. A. (1989). Genetics- a molecular approach. Chapman & Hall.
Brown T. A. (1999). Genomes. John Wiley & Sons.
Chopra V. L. (1989). Plant breeding. Oxford & IBH.
Clark M. S. and Wall W. J. (1996). Chromosomes. Chapman & Hall.

PMB(C) 306*: Project work and Dissertation (6 Credits)

PMB(C) 401: Plant Biotechnology (4 Credits)

- Unit I Plant tissue culture: Totipotency, organogenesis, micropropagation, somaclonal variations and selection; somatic embryogenesis, artificial seeds, Role of tissue culture in plant biotechnology: Anther and pollen culture, production of haploid plants and its applications; embryo culture and rescue; Somatic hybridization – methods and applications, cybrids; cell cultures for secondary metabolite production; Cryopreservation-methods and applications.
- Unit II DNA modifying enzymes and their uses in Molecular Biology; Host cells and Vectors- Host Cell Types (Prokaryotic and eukaryotic). Plasmid vectors, Bacteriophage - Lambda and M13 vectors, Cosmids, Phagemids. Artificial chromosomes (YACs, PACs, BACs, MACs and HACs). Expression vectors and gene fusion vectors.
- Unit III Cloning strategies: Use of adapters & linkers. Transgenesis: Direct gene transfer- PEG, Agrobacterium– mediated, electroporation, particle bombardment; screenable and selectable markers; useful gene transfers (herbicide resistance, insect resistance, virus resistance, drought resistance, quality improvement); safety regulations for transgenic plants.
- Unit IV PCR – basic process, types and applications. DNA sequencing- Principle of chemical and enzymatic methods. Automated DNA sequencing and high throughput sequencing. Site-directed mutagenesis and protein engineering. DNA foot printing, chromosome walking.

Suggested readings

- Bhojwani, S.S. and Razdan, M.K. (2004). Plant tissue culture: theory and practice, Revised Edition - (Studies in Plant Science), Elsevier Publications, Netherlands.
- Brown, T. A. (2006). Gene cloning and DNA analysis-an introduction. Blackwell University Press.
- Chawla, H.S. (2001). Introduction to plant biotechnology, Oxford & IBH Publishing Co.
- Chawla, H.S. (2009) Introduction to plant biotechnology, 3rd edition, Science Publishers, USA
- Desmond, S.T. N. (2004). An introduction to genetic engineering. Cambridge
- Dixon, R.A. (1995). Plant cell culture – A practical approach. IRL Press, Oxford.
- Gamborg, O.L. and Phillips, C. (1998). Plant cell tissue and organ culture: Fundamental methods. Narosa Publishing House, New Delhi.
- Lodge, J., Lund, E.T.C. and Steve, M. (2007). Gene cloning, Taylor and Francis.
- Kirsi-Marja, Oksman-Caldentey and Wolfgang, B. (2002). Plant biotechnology and transgenic plants, Marcel Dekker.
- Sambrook, J. and Russell, D.W. (2001). Molecular cloning: a laboratory manual. Cold Spring Scientific Publications.
- Slater, A., Scott, N. and Fowler, M. (2007). Plant biotechnology, Oxford University Press.
- Slater, A. Scott, N. and Fowler, M.R. (2008). Plant biotechnology: The genetic manipulation of plants, Oxford.
- Stewart, N. C. (2008). Plant biotechnology: Principles, techniques and Applications. John Wiley.
- Pal, M. ((2006). Methods in plant molecular biology. A laboratory course manual plant cell culture protocols. Second Edition. Loyola- Vargas.
- Walker J.M. and Rapley, R. (2002). Molecular biology and biotechnology. Panima.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.
- Watson, J.D., Gilman, M., Witowski, J. and Zoller, M. (1992). Recombinant DNA. Scientific American Books.

PMB (C) 402: Molecular Basis of Differentiation (4 Credits)

- Unit I Concept of totipotency; Organization of shoot apical meristem (SAM) and root apical meristem (RAM); Control of cell division and cell to cell communication; Cellular polarity; Concept of plasticity and polarity in plant development; Floral induction and development: Molecular basis of floral development and floral organ differentiation.
- Unit II Embryo and endosperm development; Pollen germination and pollen tube guidance; Pollen-pistil interaction; Self- incompatibility and its genetic control; Heterosis and apomixis; Differential behavior of male gamete; Sex determination in Plants.
- Unit III Programmed Cell Death (PCD): Senescence and its regulation; Hormonal and environmental control of senescence; Signal transduction: Basic concepts; Receptors and G-proteins; Cyclic AMP cascade; Phospholipid and Ca²⁺-calmodulin cascade; Two-component sensor-regulator system.
- Unit IV Light and temperature control of plant development: Structure and properties of phytochrome; Mechanism of light perception by phytochrome.

Suggested Readings

- Bhojwani, S.S. and Bhatnagar, S.P. (2000). The embryology of angiosperms. Vikas Publishing House.
- Brown, T. A. (2006). Genomes 3, Taylor & Francis.
- Fosket, D. E. (2006). Plant growth and development, a molecular approach, Academic Press.
- Johri, B.M. (1984). Embryology of angiosperms. Springer-Verlag.
- Leins, P., Tucker, S.C. and Endress, P.K. (1988). Aspects of flower development. J. Cramer.
- Maria, S.F. and Bozhkov, P.V. (2008). Plant embryogenesis: Methods in Molecular biology Vol. 427. Springer.
- Meeuse, A.D. (1966). Fundamentals of phytomorphology. Ronald Press Co.
- Neil, S. D. and Roberts, J. A. (2002). Plant reproduction. Annual Plant Reviews. Vol 6. CRC Press.
- Nelson, D.L. and Cox, M.M. (2013). Lehninger Principles of Biochemistry. 6th Edition, Freeman and Company, New York.
- Peter, S. (2008). Physiology and Behaviour of Plants. Wiley-Blackwell.
- Singh, R. P., Passos, L.P. (2005). Focus on plant molecular biology I: Nitric oxide signaling in Higher Plants. Studium Press, Houston, USA.
- Thomas, B. and Vince-Prue, D. (1997). Photoperiodism in plants. Academic Press.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular biology of the gene. 7th edition. Pearson.

PMB(C) 403: Lab work/ Practicals (4 Credits)

1. Callus initiation and maintenance from various explants.
2. Regeneration of shoots and roots from callus cultures.
3. Anther culture.
4. Embryo culture and rescue.
5. Protoplast isolation.
6. Synthetic seed preparation.
7. PCR amplification of genomic DNA from plants.
8. Gene cloning.
9. *Agrobacterium*- mediated genetic transformation of plants through co-culture.

10. Analysis of pollen viability.
11. Study of nuclear and cellular endosperm and suspensor through dissection and staining.
12. Isolation of globular, heart shaped and torpedo stages of embryos from suitable materials.

Suggested Readings

- Bhojwani, S.S. and Bhatnagar, S.P. (200). The Embryology of Angiosperms, Vikas Publishing House.
- Bhojwani, S.S. and Razdan, M.K. (2004). Plant tissue culture: theory and practice, Revised Edition - (Studies in Plant Science), Elsevier Publications, Netherlands.
- Brown, T. A. (2006). Gene cloning and DNA analysis-an introduction. Blackwell University Press.
- Chawla, H.S. (2009). Introduction to plant biotechnology, 3rd edition, Science Publishers, USA.
- Chawla, H.S. (2001). Introduction to plant biotechnology, Oxford & IBH Publishing Co.
- Desmond, S.T. N. (2004). An introduction to genetic engineering. Cambridge.
- Purohit S.S. (2006). A Laboratory Manual of Plant Biotechnology. 2nd revised edition. Agrobios, India.
- Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A laboratory Manual. Springer-verlag.
- Vasil, I.K. and Thorpe, T.A. (2010). Plant Cell and Tissue culture. Kluwer Academic Publishers.

PMB(C) 404*: Project work and Dissertation (6 Credits)

***PMB(C) 306 and PMB(C) 404 shall be evaluated together at the end of 4th semester for total credit strength of 12**

Attachment of students and allotment of topic for Project Work

Each faculty will be assigned a minimum of number of students to be decided by the Department. Attachment of students shall be done on the basis of their choice and marks secured by them in the last end Semester examination for which the results are available. The teacher will assign one topic to the student and communicate the same to the Head of the Department by the middle of IIIrd Semester. Modification in the topic, if absolutely necessary may be allowed during the first month of the IVth semester and not thereafter. The Head of the Department will notify the final list of topics allotted to the students. The student will work in the M. Sc. Lab or Research lab of the concerned teacher during two days in a week as per the timetable. The teacher will provide regular necessary guidance by way of discussion, tutorials and any other method, which she or he deems fit for the successful completion of work assigned to the student and will maintain the attendance. The workload for each teacher will be equivalent to five theory and six practical hours per week per student attached.

Evaluation scheme for Project Work

For continuous evaluation, she/he will be required to give four seminars, first within two months of the start of IIIrd semester and the second before the end of IIIrd Semester. The third and fourth seminars will be during the IV semester and before submission of her/ his project work at the end of the semester. Each seminar will be evaluated for 75 marks by the supervisor and Head's nominee. The marks obtained by the student in the four seminars will be averaged to obtain the total marks of continuous evaluation. The end semester examination will be based on the evaluation of project work (150 marks for dissertation + 50 marks for seminar + 25 marks for viva- voce). At the time of examination, the student will submit project report and will give a brief presentation of the work done by her/him, which will be followed by viva-voce examination. The end semester evaluation of the seminar and viva-voce will be done by a board comprising the external examiner in the concerned broad areas, supervisor and Head's nominee. However, the dissertation will be evaluated by the concerned external examiner only. The external examiners shall be called in nine broad areas to evaluate the project work. In case the external examiner is not able to come, the Dean of the School, as per existing practice may constitute an internal Board.
