DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CIRCULAR NO.SU/Sci./C.B.C. & G.S./P.G. Syll./39/2015

It is hereby inform to all concerned that, the revised Curriculum under **Choice Based Credit and Grading System** submitted by the various Ad-hoc Boards which are run at college level only and recommended by the Dean, Faculty of Science, the Hon'ble Vice-Chancellor has accepted the same on behalf of the Academic Council under Section-14[7] of the Maharashtra Universities Act, 1994 as under :-

[1]	M.Sc. Forensic Science Ist Year, Semester-I & II Progressively
[2]	M.Sc. Electronics Ist & IInd Year, Semester-I to IV Progressively
[3]	M.Sc. Industrial Automation Ist & IInd Year, Semester-I to IV Progressively [Under Innovative Programme of U.G.C.]
[4]	M.Sc. Industrial Chemistry Ist & IInd Year, Semester-I to IV Progressively
[5]	M.Sc. Herbal Technology Ist & IInd Year, Semester-I to IV Progressively [Under Innovative Programme of U.G.C.]
[6]	M.Sc. Biophysics Ist & IInd Year, Semester-I to IV Progressively
[7]	M.Sc. Bioinformatics Ist & IInd Year, Semester-I to IV Progressively
[8]	M.Sc. Plant Breeding & Molecular Genetics Ist & IInd Year, Semester-I to IV Progressively
[9]	M.Sc. Plant Biotechnology Ist & IInd Year, Semester-I to IV Progressively
[10]	M.Sc. Geology Ist & IInd Year, Semester-I to IV Progressively.

This is effective from the Academic Year 2015-16 & onwards as appended herewith.

All concerned are requested to note the contents of the circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus, ★
Aurangabad-431 004. ★
REF.NO.SU/S.S./C.B.C. & G.S. / ★
P.G.Syll./2015/ 9896-10142 ★
Date:- 20-07-2015. ★
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Director,
Board of College and
University Development.

Copy forwarded with compliments to:-

1] The Principals, affiliated concerned colleges,
Dr. Babasaheb Ambedkar Marathwada University

Copy to :-

1] The Controller of Examinations,
2] The Director, [E-Suvidha Kendra], in-front of Registrar's Quarter, Dr. Babasaheb Ambedkar Marathwada University,
3] The Superintendent, [M.Sc. Unit],
4] The Programmer [Computer Unit-1] Examinations,
5] The Programmer [Computer Unit-2] Examinations,
6] The Record Keeper.

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S*/-030815/-

Final M.Sc.Plant Biotechnology CBSC - 2 -

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.

Curriculum under Choice Based Credit & Grading System

M.Sc. Plant Biotechnology

I & II Year

Semester–I to IV

run at college level from the

Academic Year 2015-16 & onwards progressively

7/8.15

Curriculum under Choice Based Credit & Grading System

M.Sc. Plant Biotechnology

I to IV Semester

2-Year Course

SYLLABUS AT GLANCE

1st Year					1st Semester					
Subject code	Subject Name	Hrs/ Week		Exam Hrs	Theory Credits	Practical Credits	Total Credits	Total Mark		
		T	P					External	Internal	Total
PBT 401	Crop science and Crop Physiology	4	0	3	4	0	4	80	20	100
PBT 402	Principles Plant Cell Biology	4	0	3	4	0	4	80	20	100
PBT 403	Plant protection	4	0	3	4	0	4	80	20	100
PBT 404	Biostatistics	4	0	3	4	0	4	80	20	100
PBT 451	Practical Based on PBT 401	0	4	3	0	2	2	50	0	50
PBT 452	Practical Based on PBT 402	0	4	3	0	2	2	50	0	50
PBT 453	Practicals Based on PBT 403	0	4	3	0	2	2	50	0	50
PBT 454	Practicals Based on PBT 404	0	4	3	0	2	2	50	0	50
					16	8	24	520	80	600
1st Year Semester						2nd				
PBT 405	Plant Molecular Biology	4	0	3	4	0	4	80	20	100
PBT 406	Plant Biochemistry	4	0	3	4	0	4	80	20	100
PBT 407	Plant Cell Culture	4	0	3	4	0	4	80	20	100

	Technology									
PBT 408	Plant Informatics	4	0	3	4	0	4	**80**	**20**	**100**
PBT 455	Practicals based on PBT 405	0	4	3	0	2	2	50	00	50
PBT 456	Practicals based on PBT 406	0	4	3	0	2	2	50	00	50
PBT 457	Practicals based on PBT 407	0	4	3	0	2	2	50	00	50
PBT 458	Practicals based on PBT 408	0	4	3	0	2	2	50	00	50
					16	**8**	**24**	**520**	**80**	**600**

2nd Year Semester						**3rd**				
PBT 501	Plant Biotechnology and Crop Improvement	4	0	3	4	0	4	**80**	**20**	**100**
PBT 502	Principles of genetic engineering and recombinant DNA technology	4	0	3	4	0	4	**80**	**20**	**100**
PBT 503	Plant Metabolic Engineering	4	0	3	4	0	4	**80**	**20**	**100**
PBT 504	Research Methodology, Biosafety, IPR	4	0	3	4	0	4	80	20	100
PBT 551	Practicals based on PBT 501	0	4	3	0	2	2	50	00	50
PBT 552	Practicals based on PBT 502	0	4	3	0	2	2	50	00	50
PBT 553	Practicals based on PBT 503	0	4	3	0	2	2	50	00	50
PBT 554	Practicals based on PBT 504	0	4	3	0	2	2	50	00	50
					16	**8**	**24**	**520**	**80**	**600**
2nd Year Semester						**4th**				
PBT 505	Molecular Farming	4	0	3	4	0	4	**80**	**20**	**100**
PBT 506	Plant Functional Genomics	4	0	3	4	0	4	**80**	**20**	**100**
PBT 507	Molecular markers and Breeding	4	0	3	4	0	4	**80**	**20**	**100**

PBT 508	Project and Research Paper writing	0	8	3	0	8	**8**	**200**	**00**	**200**
PBT 555	Practical Based on 505	0	4	3	0	2	**2**	**50**	**00**	**50**
PBT 556	Practical based on 506	0	4	3	0	2	**2**	**50**	**00**	**50**
PBT 557	Practical Based on 507	0	4	3	0	2	**2**	**50**	**00**	**50**
					12	**14**	**26**	**590**	**60**	**650**

1st Year								1st Semester		
Subject code	**Subject Name**	**Hrs/ Week**		**Exam Hrs**	**Theory Credits**	**Practical Credits**	**Total Credits**	**Total Mark**		
		T	**P**					**External**	**Internal**	**Total**
PBT 401	Crop science and Physiology	4	0	**3**	4	0	4	**80**	**20**	**100**
PBT 402	Principles Plant Cell Biology	4	**0**	**3**	4	0	**4**	**80**	**20**	**100**
PBT 403	Plant protection	4	**0**	**3**	4	0	**4**	**80**	**20**	**100**
PBT 404	Biostatistics	4	**0**	**3**	4	0	**4**	**80**	**20**	**100**
PBT 451	Practical Based on PBT 401	0	4	**3**	0	2	2	**50**	**0**	**50**

PBT 452	Practical Based on PBT 402	0	4	**3**	0	2	2	**50**	**0**	**50**
PBT 453	Practicals Based on PBT 403	0	4	**3**	0	2	2	**50**	**0**	**50**
PBT 454	Practicals Based on PBT 404	0	4	**3**	0	2	2	**50**	**0**	**50**
					16	**8**	**24**	**520**	**80**	**600**

Subject Title: Crop Science and Physiology

Subject Code: PBT 401 4 Credits

Unit 1

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production, value addition and agro-based industries of *Rabi and Kharif* cereals and Pulses, Oil seed and Fiber crop—cotton, Jute

Unit 2

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and uses, conservation of medicinal plants, Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (*Aloe vera*, Kacholam, Stevia, , Black Musali,etc). and value addition and aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium, etc.)

Unit 3

Introduction: Why study plant physiology? Relationship of Plant Physiology to other sciences. Physiology of Plant/Crop Growth and Developmental Stages, Fruit Development, Maturation, and Ripening--Dormancy: Manifestations and Causes--Senescence in Plants and Crops—Abscission.

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants. Transpiration: the mechanism of foliar Transpiration, methods of measuring transpiration, Factors affecting transpiration- Plant or Internal Factors, Environmental or External Factors, Antitranspirants, significance of Transpiration, Gutting and bleeding. Stomatal apparatus- distribution of stomata, Stomatal Movements- starch-sugar hypothesis, the role of K+ transport for Osmatic Regulation, Osmatica in Guard Cells, Factor affecting stomatal Movements, Diffusive Capacity of stomata.

Unit 4

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants. Uptake of mineral elements in plants – Mechanisms of uptake-translocation of minerals in plants.Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition. Nitrogen metabolism: Inorganic nitrogen species (N_2, NO_3 and NH_3) and their reduction to aminoacids, protein synthesis and nucleic acids.

Unit 5

Photosynthesis-Demonstration of photosynthesis, measurement of CO_2 uptake, wilmott bubbler, Photosynthetic pigments, chlorophyll synthesis, carotenoid pigments- Role of carotenoids, The chloroplast, Photochemical, Light or Hill Reaction, the dark reaction, Products of photosynthesis, factor influencing the rate of photosynthesis, photorespiration, metabolism of photorespiration, Glycolate oxidation and CO_2 Evolution, Energetic of photorespiration. Respiration- Mechanism of Respiration,

Glycolysis, Krebs or citric Acid Cycle, Anaerobic Oxidation of pyruvic Acid, Fate of Pyruvate under aerobic conditions, oxidative phosphorylation in the Hydrogen Transport system, ATP formation, Pathway in intermediary Metabolism of carbohydrates, Regeneration of Glucose-6-Phosphate from Ribulose-5-Phosphate, respiratory Quotient, Factor affecting respiration.

Physiological Responses of Plants/Crops under Stressful (Salt, Drought, and Other Environmental Stresses) Conditions, Induction of Proteins in Response to Biotic and Abiotic Stresses. Seed physiology: Seed development, Germination, Mobilization of reserves during seed germination, seed dormancy, methods to break dormancy. Fruit Development and ripening: Chemical changes during fruit development, phytohormones in fruit growth, fruit ripening, Controlled ripening, artificial fruit ripening.

Recommended Books

1. Taiz, L. and Zeiger, E. 2010. Plant Physiology. 5th Edition. Sinauer Associates, Inc. Sunderland, Massachusetts. 782 pp.
2. Sala. Plant Physiology Laboratory Manual. Fac. Pac. The University of Montana.
3. *Introduction to Plant Physiology, Second Edition*, by William Hopkins, 1999, John Wiley and Sons, Inc. New York. (Required)
4. Das, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
5. Pal, M. ,Deka, J. and Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
6. Prasad, R. 2002(ed.). *Text Book of Field Crop Production*. ICAR.
7. Yadav, D. S. 1992. *Pulse Crops*. Kalyani.
8. Handa, S. S. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR,Jammu.
9. Hussain, A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.
10. Hussain A. 1993. *Medicinal Plants and their Cultivation.* CIMAP, Lucknow.
11. ICAR 2006. *Hand Book of Agriculture.* ICAR, New Delhi.
12. Kumar, N., Khader, Md. A., Rangaswami, J.B.M. Irulappan 1997. I*ntroduction toSpices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.
13. Prajapati, N.D., Purohit, S.S., Sharma, A.K. and Kumar, T. 2003. *A Hand Book ofMedicinal Plants: A Complete Source Book*. Agrobios.
14. Chatterjee, B.N. and Das, P.K. 1989. *Forage Crop Production - Principles and Practices*. Oxford & IBH, New Delhi.
15. Narayanan, T.R. and Dabadghao, P.M. 1972. *Forage Crops of India*, ICAR, New Delhi.
16. NAS [National Academy of Sciences]. 1979. *Tropical Legumes- Resources for the Future.* National Academy of sciences, Washington DC.
17. Skerman P.J. and Riveros F. 1990. *Tropical Grasses*. FAO Plant Production and Protection Series Food and Agriculture Organization of the United Nations, Rome.
18. Thomas, C.G. 2008. *Forage Crop Production in the Tropics* (2nd Ed.) Kalyani Publishers, Ludhiana.

Subject Title: Cell and Developmental Biology

Subject Code: PBT 402 4 Credits

Unit I

Cell Theory & Methods of Study =Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc.

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells,macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids- chloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes;Chloroplast and other photosynthetic organelles; Interphase nucleus-Structure and chemical composition; Cell division and physiology of cell division.

Membrane Structure and Function :Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata.

UNIT II

Cytoskeleton and Cell motility,Cell communication: General principles of signaling – endocrine, exocrine synapticsignaling, surface and intracellular receptors, Gproteinsand generation of secondary messenger, mode of action of cAMP and ca++

calmodulin, Target cell adaptation, cellular responses to environmental signalsin plants and animals - mechanisms of signal transduction

Organelles: Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

Unit III

Endo-membrane System and Cellular Motility :Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals.

Unit IV

Cellular Movements and Pattern Formation: Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like Fucusand Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

Unit V

Differentiation of Specialized Cells: Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in Salmonella; Mating cell types in yeast; Surface antigen changes in Trypanosomes; Heterocyst differentiation in Anabaena; Sex determination in Drosophila.

Plant Meristem Organization and Differentiation: Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem(RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixis.

Suggested Reading

1. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
6. Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
7. Brown TA. 2002. Genomes. Bios Scientific Publ.
8. Tamarin RH. 1999. Principles of Genetics. Wm C Brown Publ.
9. Griffiths AJF. 2000. An Introduction to Genetic Analysis. WH Freeman.
10. Hexter W & Yost HT. 1976. The Science of Genetics. Prentice Hall.
11. Singer M & Berg P.1991. Genes and Genomes. John Wiley & Sons.
12. Hartl DL & Jones EW. 1998. Genetics Principles and Analysis. Jones &Barlett Publ.
13. Micklos DA &Freyer G. 2003. DNA Science - A First Course. CPL Scientific Publ.
14. Brooker RJ. 2004. Genetics Analysis and Principles. Addison-Wesley Longman.
15. Watson JD. 2004. Molecular Bilology of the Gene. Pearson Edu.
16.

Subject Title: Plant protection

Subject Code: PBT 403 4 Credits

Unit 1

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Structure, morphology, life cycle and classification of bacteria, fungi

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators.

Unit 2

History of plant viruses, composition and structure of viruses.The origin and evolution of virus.Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship.Virus nomenclature and classification, genome organization, replication and movement of viruses.

Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics. Bioassay of Plant Viruses and serological properties.satellite viruses, satellite RNAs, viroids, virusoids, prions.

Unit 3

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes.Strategies for gene deployment. Breeding for disease resistance

Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction. Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral induced gene silencing.

Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, Biosafety issues related to GM crops.

Unit 4

Diseases of Cereal crops- wheat, oats, barley, rice, pearl millet, sorghum,maize, ragi and other minor millets. Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea. Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed,sunflower, groundnut, castor. Diseases of Cash crops- cotton, sugarcane and tobacco.

Introduction, symptoms and etiology of different fruit diseases like banana, mango, citrus, papaya, pineapple, sapota, grapes, guava and management of the diseases.

Symptoms, mode of perpetuation of diseases of plantation crops such as coconut, arecanut, oilpalm, cashew, cocoa, tea, coffee, rubber and their management

Unit 5

Scope and importance of insect anatomy and physiology.Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

Classification and nomenclature of Insect, study of important Insect orders, Pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars etc., Pests of pulses, tobacco, oilseeds and their management, Pests of fibre crops, forages, sugarcane and their management

Pest of Horticulture and Plantation crops-- Fruit Crops- mango, banana, pomegranate, grapes, citrus, Vegetable crops- tomato, potato, cole crops, French beans, chow-, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc. Plantation crops- coffee, tea, rubber, coconut, arecanut, cashew, oil palm, date palm, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, cinnamon, turmeric, ginger, betlevine etc.

Recommended Books

1. Molecular Plant Pathology by Mathew Dickson and James Beynon, Sheffield Annual Plant reviews, Vol.4

2. Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ.,

Subject Title: Biostatistics

Subject Code: 404 4 Credits

Objective:

1. To introduce the need for statistics and statistical analysis

2. To describe the types of data
3. To present descriptive statistics
4. To introduce the fundamental probability basis
5. To discuss random variables and their distributions
6. To utilize probability distributions to perform statistical inference
7. To provide experience in a quantitative research study

UNIT I

Statistical Methods in Agriculture Presentation of Data: Frequency distributions; graphical presentation of data by histogram, frequency polygon, frequency curve and cumulative frequency curves.

Measures of Locations and Dispersion: Mean, median, mode and their simple properties (with-out derivation) and calculation of median by graphs; range, mean deviation, standard deviation, standard error, coefficient of variation.

UNIT II

Probability and Distributions: Random distributions; events exhaustive, mutually exclusive and equally likely; definition of probability (with simple exercises); definitions of binomial, Poisson and normal distributions; and simple properties of the above distributions (without derivation).

UNIT III

Correlation and Regression: Bivariate data-simple correlation and regression coefficients and their relation; Spearman rank correlation; limits of correlation coefficient; effect of change of origin and scale on correlation coefficient; linear regression and equations of line of regression; association and independence of attributes.

UNIT IV

Sampling: Concept of population and sample; random samples; methods of taking a simple random sample. Tests of significance: Sampling distribution of mean and standard error; z and t-test (equality of means; paired and unpaired t-test); t-test for comparison of means when variances of two populations differ; Chi- square test for

goodness of fit; independenceof attributes, and homogeneity of samples; interrelation between t-test and F-Test

UNIT V

Principles of Design of experiments: randomization, replication and local control. Choice of size and type of a plot using uniformity trials. CRD, Randomized block design. Concept and definition of efficiency of design.Comparison of efficiency between CRD and RBD. Latin square Design : Lay-out, ANOVA table. Comparison of efficiencies between LSD and RBD; LSD and CRD

Missing plot technique ; estimation of missing plots by minimizing error sum of squares in RBD and LSD with one or two missing observations. Factorial Experiments : general description of factorial experiments; 2^2, $2^3$and 2n factorial experiments arranged in RBD and LSD. Definition of main effects and interactions in 2^2 and 2^3 factorial experiments.Preparation of ANOVA by Yates procedure.Estimates and tests for main and interaction effects (Analysis without confounding).

Recommended Books

1. Goulden, C.H. (1952). Methods of Statistical Analysis, 2/e, John Wiley, New York.
2. Hoshmand A. Reza 1988. Statistical Methods for Agricultural Sciences. Timber Press, Portland, Oregan, USA.
3. Kempthorne, O. (1957). An Introduction to Genetic Statistics, John Willey, New York.
4. Kempton RA and Fox PN (1997). Statistical Methods for Plant Variety Evaluation. Chapman and Hall
5. Panse, V.C. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.
6. Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods, 7/e. Iowa State Univ. Press, Ames, Iowa.
7. Steel, R.G.D. and Torrie , H.H. (1960). Principles and Procedures of Statistics. McGraw- Hill, New York.
8. Gomez, AG and Gomez, AA (1994). Statistical Procedures for Agricultural Research, 2/e. John Wiley & Sons, New York.
9. Agresti A. 2002. Categorical Data Analysis. 2nd Ed. John Wiley.

10. Arnold BC, Balakrishnan N &Nagaraja HN. 1992. A First Course in Order Statistics. John Wiley.
11. David HA &Nagaraja HN. 2003. Order Statistics. 3rd Ed. John Wiley.
12. Dudewicz EJ & Mishra SN. 1988. Modern Mathematical Statistics. John Wiley.
13. Huber PJ. 1981. Robust Statistics. John Wiley.
14. Johnson NL, Kotz S &Balakrishnan N. 2000. Continuous Univariate Distributions. John Wiley.
15. Johnson NL, Kotz S &Balakrishnan N. 2000. Discrete Univariate Distributions. John Wiley.
16. Marek F. 1963. Probability Theory and Mathematical Statistics. John Wiley.
17. Rao CR. 1965. Linear Statistical Inference and its Applications. John Wiley.
18. Rohatgi VK &Saleh AK Md. E. 2005. An Introduction to Probability and Statistics. 2nd Ed. John Wiley.

PBT 451	Practical Based on PBT 401
PBT 452	Practical Based on PBT 402
PBT 453	Practicals Based on PBT 403
PBT 454	Practicals Based on PBT 404

PBT 451 Practicals based on PBT 401

(Minimum 12 Practicals conduct)

Are leaves good predictors of climate?

Primer on Seed Germination

Idioblasts in *Dieffenbachia*

Pigment composition of RCBr

Awn Movement in *Stipa* sp. - A Primer on Time Lapse Movies *(includes Pre & Post labs)*

Independent Research Project

Measuring Water Potential In Potato Tissue

Measuring Stomatal Frequency in Broad Bean

Plant Root Culture

Measuring Photosynthesis with a Qubit CO_2 Gas Analyzer; Starch Prints

Ecophysiological Analysis of Leaf Shape

Surface-to-Volume Ratios in Biology

Gravitropism in Dandelion Scapes

Phytochrome Experiments

Measuring Chlorophyll (& Anthocyanin) Concentrations in plant tissues

Measuring Photosynthesis in Green and White Regions of a Variegated Leaf

Starch Prints

Quantification of Anthocyanin in Red Cabbage (*Brassica oleracea*)

Protoplasts; Protoplast Images

Idioblasts in *Dieffenbachia*

Fruit Development in Rapid Cycling *Brassica rapa* (RCBr)

Seed Germination (Brief Primer on Seed Germination; Germination Percentage & Rate; Testing Seed Viability; Light and Seed Germination; Seedling Photomorphogenesis (Etiolation Lab - different version); Seed packet analysis; Test Yourself; Seedling Structure (eudicot vs. monocot; epi vs. hypogaeous0

Light (Photomorphogenesis , Light & Plants)

・・ Phonological studies at different growth stages of crop

・・ Estimation of crop yield on the basis of yield attributes

・・ Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

・・ Working out growth indices (CGR, RGR, NAR, LAD), LER, aggressiveness, relative crowding coefficient, monetary yield advantage and ATER (Area Time Equivalent Ratio) of prominent intercropping systems of different crops

- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Identification of crops based on morphological and seed characteristics
- Cultivation techniques of medicinal and aromatic plants
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants and value addition.
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants

-Canopy measurement, yield and quality estimation, viz. crude protein, NDF,ADF, lignin, silica, cellulose etc. of various fodder and forage crops

- Anti-quality components like HCN in sorghum and such factors in other crops
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops

・・ Visit of field experiments on cultural, fertilizer, weed control and watermanagement aspects

・・ Visit to nearby villages for identification of constraints in crop production

PBT 452 Practicals based on PBT 402

1. Microscopy – Bright field, dark field, phase contrast, fluorescence microscopy, visit to Electron microscope and Confocal microscope facilities.
2. Histology – Hand-sectioning of stem and leaf, saffranin and fast green staining.
3. Microtomy - fixing of tissues, dehydration, wax-embedding, sectioning and staining.
4. Mitosis – Onion root tips
5. Meiosis – Insect testes
6. Morphogenesis in tobacco leaf tissue.
7. Regeneration Abilities of the Shoot Apical Meristem (SAM).
8. The Effects of Different Light Wavelengths on Germinating Corn Embryos.
1. Morphological study of mitotic & meiotic chromosomes
9. Cell fractionation
10. Sterilization methods (Autoclaving, Hot air oven, radiation and filtration)
11. Preparation of routine microbiological media
12. Microscopic observation, Staining and identification of bacteria, fungi and algae
13. Culturing & preservation of microorganisms: Tube culture (slant/broth), plate culture, flask culture & preservation
14. Isolation of bacteria, fungi, algae and bacteriophages
15. Measurement of microbial growth (Viable count and turbidometry) 9. Study for bacterial growth curve

PBT 453 Practicals based on PBT 403

16. As per the subject requirement conduct minimum 10 practicals

PBT 454 Practicals based on PBT 404

1. Analysis of variance
2. Partioning of total genetic variance in various models
3. Correlation and regression analysis
4. Path coefficient analysis
5. Discriminant function analysis

6. Practicals related to Unit I,II and III should conduct as per theory

7. Large sample tests.

8. Analysis of variance in one-way and two-way classification (with and without interaction terms).

9. Analysis of a Latin square design. Factorial Experiment Practical.

10 Analysis of variance in RBD and LS design with one or two missing observations.

11. Drawing a simple random sample with the help of table of random numbers.

12. Estimation of population means and variance in simple random sampling.

13. Stratified random sampling for population mean (proportional and optimum allocation).

14. Ratio and regression estimation of population mean and total.

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression coefficients and regression equations; Fitting of Pearsonian curves; Analysis of association between attributes, categorical data and log-linear models.

1st Year		2nd Semester								
Subject Code	Subject Title	Hrs/ Week		Exam Hrs	Theory Credits	Practical Credits	**Total Credits**	**Marks**		
								External	**Internal**	**Total**
PBT 405	Plant Molecular Biology	4	0	3	4	0	4	**80**	**20**	**100**
PBT 406	Plant Biochemistry	4	0	3	4	0	4	**80**	**20**	**100**
PBT 407	Plant Cell Culture Technology	4	0	3	4	0	4	**80**	**20**	**100**
PBT 408	Plant Informatics	4	0	3	4	0	4	**80**	**20**	**100**
PBT 455	Practicals based on	0	4	3	0	2	2	50	00	50

	PBT 405									
PBT 456	Practicals based on PBT 406	0	4	3	0	2	2	50	00	50
PBT 457	Practicals based on PBT 407	0	4	3	0	2	2	50	00	50
PBT 458	Practicals based on PBT 408	0	4	3	0	2	2	50	00	50
					16	**8**	**24**	**520**	**80**	**600**

Subject Title: Plant Molecular Biology

Subject Code: PBT 405 4 Credits

Objective :

1. Understand Basic Molecular Genetic Processes
2. Be able to interpret results from basic Molecular Genetic experiments
3. Be able to critically review the molecular genetic primary literature in their field of interest
4. Be able to develop hypothesis and develop experiments to test these hypothesis in the Molecular Genetic aspects of their chosen fields
5. Have "hands on" experience with Molecular Genetic Techniques in a multi-step research project

UNIT I

Genetic material: DNA and RNA as genetic material (experimental evidences); structure of DNA (including Z-DNA, and Shasisekharan's RL model); supercoiling of DNA; different types of RNAs and their roles; differences between DNA and RNA.

Organization of genetic material: Chromosome ultra-structure and nucleosome concept; packaging of DNA as nucleosomes in eukaryotes; techniques used for discovery of nucleosome; structure and assembly of nucleosomes, solenoid; phasing of nucleosomes; DNA content and C- value paradox, repetitive and unique sequences; overlapping, pseudo, cryptic and split genes; satellite DNA's; selfish DNA (including transposons and retroposons); Centromere and telomere.

UNIT II

DNA replication (in prokaryotes and eukaryotes): Unwinding proteins; role of RNA polymerases for synthesis of RNA primers, DNA polymerases in prokaryotic and eukaryotic DNA replication; semi- conservative, discontinuous and bi-directional replication; RNA primers; role of a number of proteins in prokaryotic and eukaryotic DNA replication; models of replication. 4

UNIT III

Transcription of message: Central dogma (including reverse transcription), prokaryotic RNA polymerases and eukaryotic RNA polymerases (I to V); promoters for transcription initiation (pribnow box, TATA box, CAAT box, GC box, etc.); enhancers and silencers; transcription initiation complex (including scaffold complex); different transcription factors for different RNA polymerases in eukaryotes (including mediators); DNA binding and activation domains in transcription factors; elongation of RNA transcript; termination of transcription. 8

Processing of RNA transcript: Different mechanisms of RNA splicing; spliceosomes; alternative splicing (exosomes); ribozymes; snRNAs;; RNA editing (editosomes)

UNIT IV

Genetic code (including mitochondria genetic code): Deciphering of code *in vitro* and *in vivo* (use of mutations -base replacement, frame shift and suppressor mutations. 2

Protein synthesis apparatus: Transfer RNA and ribosomes (including Rosen Kornberg's work); transfer RNA synthetases and second genetic code. 2

Translation of message: Initiation in prokaryotes and eukaryotes; Kozak's hypothesis; role of initiation factors; initiation complex; elongation of polypeptide (EF – Tu, EF – Ts& EF-G; eEF1 and eEF2); termination of polypeptide.

Maturation and modification of released polypeptide: Transport and modification of polypeptide and signal peptidases; protein splicing of inteins; elementary idea of protein folding; protein degradation (ubiquitin and proteasome).

UNIT V

Regulation of gene expression in prokaryotes: The operon concept and its recent modifications, positive and negative controls; leader sequence and attenuation; feedback inhibition.

Regulation of gene expression in eukaryotes: Regulation of transcription, Britten–Davidson model, histone and non-histone proteins in regulation, signal transduction pathways, transcription factors (DNA-binding and activation domains), rearrangement of DNA; post-transcriptional regulation-alternative splicing, mRNA stability and translational control, UTRs of mRNA, miRNA, siRNA, riboswitches, antiswitches.

Suggested Readings

1. Bruce A.2004. Essential Cell Biology. Garland.
2. Karp G.2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.
3. Klug WS & Cummings MR 2003. Concepts of Genetics. Scot, Foreman & Co.
4. Lewin B. 2008. IX Genes. John Wiley & Sons
5. Lodish H, Berk A &Zipursky SL. 2004. Molecular Cell Biology. 5TH Ed. WH Freeman.
6. Nelson DL & Cox MM. 2005. Lehninger's Principles of Biochemistry. WH Freeman & Co.
7. Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
8. Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley Publ. Co.

9. Lewin B. 2008. Genes IX. John Wiley & Sons.
10. Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley.
11. Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
12. Brown TA. 2002. Genomes. Bios Scientific Publ.
13. Tamarin RH. 1999. Principles of Genetics. Wm C Brown Publ.
14. Griffiths AJF. 2000. An Introduction to Genetic Analysis. WH Freeman.
15. Hexter W & Yost HT. 1976. The Science of Genetics. Prentice Hall.
16. Singer M & Berg P.1991. Genes and Genomes. John Wiley & Sons.
17. Hartl DL & Jones EW. 1998. Genetics Principles and Analysis. Jones &Barlett Publ.
18. Micklos DA &Freyer G. 2003. DNA Science - A First Course. CPL Scientific Publ.
19. Brooker RJ. 2004. Genetics Analysis and Principles. Addison-Wesley Longman.

Watson JD. 2004. Molecular Bilology of the Gene. Pearson Edu.

Subject Title: Plant Biochemistry

Subject Code: PBT 406 4 Credits

Objective:

1. Students will learn the stucture, function and biosynthetic pathways of essential biochemical molecules including their key chemical and physical properties.
2. Students will understand plant cell structure and organization and apply specific biochemical functions to all components of plant cell structure.
3. Students will learn amino acid structures and relate their chemical properties to the synthesis and function of proteins and enzymes .
4. Students will understand how light energy is captured and used to provide chemical forms of energy to power the functions of cells and whole plants.

5. Students will learn about the rich diversity of secondary compounds and metabolism in plants and how such compounds contribute to human health.

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.classification and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT III

Metabolism of carbohydrates (Glycolysis, TCA cycle, electron transport chain) photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. Nutritional aspects of carbohydrates, lipids, proteins and minerals.

Photosynthetic pigments in relation to their functions, photosynthesis, C3, C4 and CAM pathways, photorespiration. Sucrose-starch interconversion,

UNIT IV

Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur in to amino acids.Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction.

UNIT V

Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Recommended Books

1. Conn EE &Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.
2. Metzler DE. *Biochemistry.* Vols. I, II. Wiley International.
3. Nelson DL & Cox MM. 2004. *Lehninger's Principles of Biochemistry*.MacMillan.
4. Voet D &Voet JG. *Biochemistry*. 3rd Ed. Wiley International.
5. Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry andMolecular Biology of Plants.* 2nd Ed. John Wiley.
6. Dey PM &Harborne JB. 1997. *Plant Biochemistry*. Academic Press.
7. Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*.Pergamon Press.
8. Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ.Press.

Subject Title: Plant Cell Culture Technology

Subject Code: PBT 407 4 Credits

UNIT I

Historyofplantcellandtissueculture; cellular totipotency, differntiation, dedifferntiation and redifferntation. Molecular basis of plantorgandifferentiation Culturemedia;Varioustypesof culture; callus,suspension, nurse,root,meristem, etc. organogenesisandsomaticembryogenesis;Plantgrowth regulators: modeofaction,effecton*invitro*cultureandregeneration.

Plant Micropropagation –Introduction--Methods and approaches--Explants and their surface disinfection--Culture media and their preparation --Stages of Micropropagation--Techniques of Micropropagation.

Plant Regeneration – Somatic Embryogenesis—Introduction --- Methods and approaches --Selection of the cultivar and type of explant--Culture media--Preparation of culture media--Sterilization of tissues and sterile technique--Culture and growth of tissue--Culture and induction of somatic embryos--Embryo development--Transfer to soil – the final stage of regeneration--Troubleshooting. Haploid Plants—Introduction--Methods and approaches—Androgenesis—Diploidization --Troubleshooting.

UNIT II

Embryo Rescue—Introduction--Methods and approaches--Identification of the time and type of barrier in hybridization--Isolation of plant material after fertilization—Culture conditions and media--Confirmation of hybridity and ploidy--Conditions for regeneration of embryos to plants--Troubleshooting.

UNIT III

Cryopreservation of Plant Germplasm—Introduction ---Methods and approaches--Main principles---Slow (two-step) freezing---Vitrification ---Encapsulation–dehydration---DMSO droplet freezing--- Combined

methods.Plant Protoplasts: Isolation, Culture and Plant Regeneration--- Introduction ---Methods and approaches--- Protoplast isolation ---Protoplast culture ---Troubleshooting. Protoplast Fusion Technology – Somatic Hybridization and Cybridization –Introduction--- General applications of somatic hybridization --- Methods and approaches –Troubleshooting

UNIT IV

Secondary Products—Introduction --- Methods and approaches ---Plant cell cultures --- Scale-up and regulation of secondary metabolite production-- Detection of secondary products ---Troubleshooting. Plant Cell Culture – Present and Future—Introduction ---Micropropagation –Embryogenesis --- Background ---Commercial exploitation of somatic embryos ---Molecular aspects of somatic embryogenesis---Microspore derived embryos –Haploid methodology---Haploids and their exploitation--- Induction of haploid plants.

UNIT V

Micropropagation of commercially important plant species; plant multiplication,hardening,andtransplantation;geneticfidelity;scalingup and cost reduction. Somecasestudiesonsuccessstoriesoncommercialapplicationsofplant tissue culture.

Suggested Reading

1. Plants from Test Tubes: An Introduction to Micropropagationby LydianeKyte
2. Plant Propagation: Principles and Practices (6th Edition) by Hudson T. Hartmann, Dale Kester, Fred Davies, and Robert Geneve
3. Plant Propagation by Alan Toogood
4. Plant Cell Culture: Essential Methods--Michael R. Davey, Paul Anthony

Subject Title: Plant Informatics

Subject Code: PBT 408 4 Credits

Objective:

Introduce students to the current bioinformatics algorithms/concepts and their implementations.

Teach students to cast a molecular biology problem as a bioinformatic problem, provide them with the skills necessary to independently select relevant tools, optimize their settings, and build pipelines to solve the set problem.

Prepare students for more advanced bioinformatics courses involving method development.

UNIT I

Basic of Bioinformatics

Introduction-- What is bioinformatics?--Basic concepts--Protein and amino acid --DNA & RNA -- Sequence, structure and function

Bioinformatics databases—Introduction -- Type of databases-- Nucleotide sequence databases -- Primary nucleotide sequence databases—EMBL – GeneBank – DDBJ-- Secondary nucleotide sequence databases – UniGene – SGD -- EMI Genomes – Genome Biology -- Protein sequence databases -- SwissProt/ TrEMBL – PIR -- Sequence motif databases – Pfam –PROSITE -- Protein structure databases -- Protein Data Bank – SCOP – CATH -- Other relevant databases – KEGG – PQS –DockGround

Sequence alignment and database searching

Single sequence alignments -- Biological motivation -- Pairwise alignments -- Scoring matrix PAM – BLOSUM -- Gap penalty -- Dynamics programming --Needleman-Wunsch -- Smith- Waterman -- Heuristic methods – FASTA – BLAST -- Statistics of sequence alignment score -- E-Value -- P-Value -- Multiple sequence alignments – ClustalW – Profile -- Profile- sequence alignment -- Profile-profile alignment -- PSI-BLAST -- Hidden Markov Models -- Viterbi algorithm -- HHM based multiple-sequence alignment ---SAM

Phylogenetics -- Sequence-based taxonomy --- Why Phylogenetics? -- Models, assumptions, and interpretations -- From multiple alignment to phylogeny – Neighbor joining -- Maximum likelihood and parsimony -- Computer tools for phylogenetic analysis – DISTANCES – GROWTREE --- PAUP – PHYLIP

Protein structure alignments -- What is structure superposition? – RMSD -- TM-score -- What is structure alignment? -- Different structure alignment algorithms – DALI – CE – VAST -- TM-align -- Number of protein folds in PDB

UNIT II

PROTEIN STRUCTURE

Protein function -- Sequence to function --- Structure to function -- Protein function -- identification methods and databases

Protein secondary structure predictions-- What is protein secondary structure? -- Hydrogen bond -- How to define a secondary structure element? --- Methods for predicting secondary structure -- Chou and Fasman method – PHD – PSIPRED -- SAM

Protein tertiary structure modeling -- Basic concepts -- Protein folding and dynamic simulation -- Comparative modeling – Modeller -- Swiss-Modeller – Threading -- What is threading? -- Bowie-Luthy-Eisenberg -- Profile-profile alignment – GenThreader --

PROSPECTOR --FFAS03 -- Meta-threading -- 3D-jury – LOMETS -- Ab initio modeling -- Anfinsen thermodynamic hypothesis – UNRES – ROSETTA – TOUCHSTONE – Combined modeling approaches -- TASSER/I-TASSER -- CASP: A blind protein structure prediction competition

Experimental methods for protein structure determination -- X-ray crystallography -- Diffraction theory -- Phase determination -- Calculating and interpreting electron density maps -- Model building and refinement -- Structure assessment -- Crystallization of macromolecules -- Dynamic crystallography -- Nuclear magnetic resonance (NMR) -- Classical NMR spectroscopy -- Theoretical description of NMR spectroscopy -- Experimental aspects of NMR spectroscopy –

Relaxation and dynamic processes -- Heteronuclear NMR experiments -- Sequential assignment and structure calculations

UNIT III

PROTEIN-PROTEIN INTERACTIONS

Experimental identification of protein-protein interactions

Yeast two-hybrid assay -- High-throughput mass spectrometry -- Interaction networks and system biology

Protein quaternary structure modeling --Basic concepts -- Degrees of freedom -- Presentation of protein conformations -- Hydrophobicity factor -- Shape complementary -- Docking Scoring function -- Protein-protein docking algorithms -- Fast Fourier Transformation (FFT) – GRAMM -- Semi-flexible docking: Side-chain refinement -- Clustering and refinement -- Protein-ligand docking algorithms -- Drug design -- Multiple-threading algorithms -- Homology modeling of protein-protein interactions -- Protein and ligand binding – CAPRI

UNIT IV

BIOMOLECULAR SIMULATIONS

Basic concepts -- Units and derivatives -- Force field and energy landscape -- Truncation of nonbonded interactions --

Conformational Sampling—Introduction -- Minimization and algorithms – Molecular dynamics -- Ensembles (statistical mechanics) -- Monte Carlo simulations

Solvation -- Introduction -- Periodic boundary condition --Ewald summation – Implicit solvent model and continuum electrostatics -- Monte Carlo simulation on parallel computers

Advanced Techniques – Introduction -- Replica-exchange simulations -- Restraint potentials -- Free energy calculations -- Membrane simulations

UNIT V

SELECTED TOPICS

Biological membranes – Introductions -- Biological roles -- Structural features – Membrane lipids -- General structures -- Aggregation states --- Polymorphism -- Thermal transitions Electrostatic effects -- Molecular dynamics --- Membrane proteins – Crystallization -- Overview of structure features -- Structure/function relations -- Selected topics in membrane proteins -- simulation of Membrane proteins

Recommended Books

1) *Fundamental Concepts of Bioinformatics*, Dan E. Krane and Michael L. Raymer, San Francisco: Benjamin Cummings, 2003. ISBN: 0-8053-4633-3

2) *Bioinformatics: A Practical Guide to the analysis of genes and proteins* edited by Andreas D. Baxevanis, B.F. Francis Ouellette, New York: Wiley-Interscience, 2001, second edition. ISBN: 0-471-38391-0

PBT 455 Practicals based on PBT 405

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in a bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

DNA EXTRACTION Spectrophotometry &Fluorometry Restriction Enzyme Digestion Agarose Gel Electrophoresis PCR PRIMER DESIGN, PCR REACTIONS Agarose Gel Electrophoresis, CLONING Ligation, Transformation Incubation, Plating, CLONING, pick colonies CLONING/SEQUENCING PCR colony screen Agarose Gel Electrophoresis Plasmid purification Agarose Gel Electrophoresis, SOUTHERN Agarose Gel Electrophoresis Blotting, RNAExtraction& Quantification and qualitative test, RNA Denaturing Agarose Gel Electroph. RNA RT-PCR RT2 –PCR, TRANSFORMATION Transient Plant seeds, TRANSFORMATION
Harvest and Stain, TRANSFORMATION View Transient Transformants Screen Transformant seedlings

PBT 456 Practicals based on PBT 406

Preparation of standard and buffer solutions.
Extraction and estimation of sugars and amino acids.
Estimation of proteins by Lowry's method.
Estimation of DNA and RNA by Diphenylamine and orcinol methods.
Estimation of ascorbic acid.
Separation of biomolecules by TLC and paper chromatography
Analysis of plant samples
Estimation of proximate constituents Ca, Mg and trace elements
Estimation of carbohydrates – Proteins – oils and fats, crude fibres –
Analysis of sugars in cane juice –
Assessment of quality of feed and forage crops –
Estimation of sugars, vitamin in fruits and vegetables –
Estimation of alkaloids and tannin
Estimation of toxin in feeds and forage crops
Tissue test – Identification of deficiency and toxicity symptoms.

PBT 457 Practicals based on PBT 407

Callus, Suspension Culture, and Hairy Roots. Induction, Maintenance and Characterization, Callus Culture and Regeneration

Growth Measurements: Estimation of Cell Division and Cell Expansion

Measurement of Cell Viability

Culturing of Plant Cell Suspension Cultures

Induction of Plant Defense Responses

Extraction of Media for Phytoalexins (Antibiotics)

Bioassay for Phytoalexins (Antibiotics)

Measuring De Novo Synthesis Rates of a Metabolite

Measuring De Novo Synthesis Rates of an Intracellular Metabolite

Enzyme Assay for SesquiterpeneCyclase

PARTIAL PURIFICATION OF THE SESQUITERPENE CYCLASE

Determination of Km and Vmax for sesquiterpenecyclase

Induction Time Course of SesquiterpeneCyclase Activity in Elicitor-Treated Cells

Immunodetection of the SesquiterpeneCyclase Protein

Growth Measurements: Estimation of Cell Division and Cell Expansion

Callus and Suspension Culture Induction, Maintenance, and Characterization

Measurement of Cell Viability in In Vitro Cultures

Cryopreservation of Embryogenic Cell Suspensions by Encapsulation-Vitrification

Somatic Embryogenesis in Picea Suspension Cultures

Indirect Somatic Embryogenesis in Cassava for Genetic Modification Purposes

Direct Somatic Embryogenesis in Coffeacanephora

Protocol to Achieve Photoautotrophic Coconut Plants Cultured In Vitro With Improved Performance Ex Vitro

Efficient Method for the Micropropagation of Agave Species

Clonal Propagation of Softwoods

Isolation, Culture, and Plant Regeneration From Leaf Protoplasts of Passiflora

Isolation, Culture, and Plant Regeneration From Echinacea purpurea Protoplasts

Production of Cybrids in Brassicaceae Species

Guard Cell Protoplasts: Isolation, Culture, and Regeneration of Plants

Production of Interspecific Hybrid Plants in Primula

Capsaicin Accumulation in Capsicum spp. Suspension Cultures

Isolation and Purification of Ribosome-Inactivating Proteins

Catharanthusroseus Shoot Cultures for the Production of MonoterpenoidIndole Alkaloids

Methods for Regeneration and Transformation in Eschscholziacalifornica: A Model Plant to Investigate Alkaloid Biosynthesis

PBT 458 Practicals based on PBT 408

2nd Year										
						3rd Semester				
Subject Code	Subject Title	Hrs/ Week		Exam Hrs	Theory Credits	Practicals Credits	Total Credits	Marks		
		T	P					External	Internal	Total
PBT 501	Plant Biotechnology and Crop Improvement	4	0	3	4	0	4	**80**	**20**	**100**
PBT 502	Principles of genetic engineering and recombinant DNA technology	4	0	3	4	0	4	**80**	**20**	**100**
PBT 503	Plant Metabolic Engineering	4	0	3	4	0	4	**80**	**20**	**100**
PBT 504	Research Methodology, Biosafety, IPR	4	0	3	4	0	4	80	20	100
PBT 551	Practicals based on PBT 501	0	4	3	0	2	2	50	00	50
PBT 552	Practicals based on PBT 502	0	4	3	0	2	2	50	00	50
PBT 553	Practicals based on PBT 503	0	4	3	0	2	2	50	00	50

PBT 554	Practicals based on PBT 504	0	4	3	0	2	2	50	00	50
					16	8	24	520	80	600

Subject Title: Plant Biotechnology and Crop Improvement 4 Credits

Subject Code: PBT 501

Unit 1

Conventional versusnon-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement.

Unit 2

Techniques for plant transformation: Introduction- Agrobacterium-mediated gene transfer--The biology of Agrobacterium--The Ti plasmid--Ti-plasmid features--The process of T-DNA transfer and integration--Practical applications of Agrobacterium-mediated plant transformation--Transformation in planta--Direct gene transfer methods--Particle bombardment--Polyethylene glycol (PEG)-mediated transformation-Electroporation--Silicon carbide fibers—WHISKERS

Binary vectors for plant transformation: Introduction--Desirable features of any plasmid vector--Development of plant transformation vectors--Basic features of vectors for plant transformation--Promoters and terminators--Selectable markers---Reporter genes--Origins of replication--Co-integrative and binary vectors--Families of binary vectors—

Optimization--Arrangement of genes in the vector--Transgene copy number--Transgene position--Transgene features--Clean gene technology. **The genetic manipulation of herbicide resistance**: Introduction--The use of herbicides in modern agriculture--What types of compounds are herbicides?--Strategies for engineering herbicide resistance--Prospects for plant detoxification systems--Commercialization of herbicide-resistant plants to date--The environmental impact of herbicide-resistant crops--The development of 'super weeds'.

Unit 3

The genetic manipulation of pest resistance: Introduction-The nature and scale of insect pest damage to crops--GM strategies for insect resistance: The Bacillus thuringiensis approach to insect resistance--The use of 'Bt' as a biopesticide--Bt-based genetic modification of plants--The problem of insect resistance to Bt--The environmental impact of Bt crops--The 'Copy Nature' strategy--Insect resistant crops and food safety.

Plant disease resistance: Introduction--Existing non-GM approaches--Plant-pathogen interactions—Prokaryotes--Fungi and water moulds—Viruses--Natural disease resistance pathways--overlap between pests and diseases---Anatomical defences--Pre-existing protein and chemical protection--Inducible systems--Systemic responses--Biotechnological approaches to disease resistance--Protection against fungal pathogens--Antimicrobial proteins--Induction of HR and SAR in transgenic plants

Viral resistance: Introduction-The transgenic approach—PDR--Interactions involving viral proteins.

Unit 4

Strategies for engineering stress tolerance: Introduction-The nature of abiotic stress-The nature of water-deficit stress--Different abiotic stresses create a water deficit--Targeted approaches towards the manipulation of tolerance to specific water-deficit stresses-Alternative approaches to salt stress--Alternative approaches to cold stress--Tolerance to heat stress--Secondary effects of abiotic stress--the production of reactive oxygen species--Expression of enzymes involved in scavenging ROS--Production of antioxidant

The improvement of crop yield and quality: Introduction--The genetic manipulation of fruit ripening--Engineering plant protein composition for improved nutrition—carbohydrate, protein, lipid and vitamins.

Unit 5

F**uture prospects for GM crops:** Introduction--The current state of transgenic crops--Who has benefited from these first-generation crops?--What will drive the development of the future generations of GM crops?--Concerns about GM crops--Antibiotic resistance genes--Herbicide resistance and 'super-weeds'--Gene containment--Big business--The regulation of GM crops and products. Future developments in the science of plant biotechnology--'Greener' genetic engineering.

Subject Title: Principles of genetic engineering and recombinant DNA technology

Subject Code: 502 4 Credits

Unit 1

Fundamental techniques of gene manipulation, cutting and joining DNA molecules-cutting DNA molecules-joining DNA molecules

Defining purview of genetic engineering: Tools and techniques Properties and applications of DNA Modifying Enzymes: Host controlled restriction modification system (Nomenclature, Type I-IV restriction endonucleases, Isoschizomers); DNA Methyltransferases; DNA polymerases; Special case of thermo-stable DNA polymerases in context to PCR (History, concept, enzymology, applications); Reverse transcriptases in context to semi-quantitative and quantitative RT-PCR

Basic biology of plasmid and phage vector-plasmid biology and simple plasmid-bacteriophage λ--DNA cloning with single stranded DNA vector

Cosmid, phasmids, and other advanced vectors-vector for cloning large fragments of DNA-specialist purpose vectors

Unit 2

Gene cloning strategies – Genomic DNA libraries are generated by fragmenting the genome and cloning overlapping fragments in vectors—The PCR can be used as an alternative to genomic DNA cloning-complementary DNA (cDNA) libraries are generated by the reverse transcription of mRNA- The PCR can be used as an alternative to cDNA cloning-Many different strategies are available for library screening-Difference cloning exploits difference in the abundance of particular DNA fragments, Sequencing genes and short stretches of DNA, Changing genes: site directed mutagenesis and protein engineering-protein engineering, protein engineering

Unit 3

Gene transfer to Planta—introduction –Plant tissue culture-major strategies for gene to plant cells –Agrobacterium-mediated transformation-Direct DNA transfer Plants—gene targeting in plants-Plant viruses can be used as episomal expression vector

Types of vectors: Plasmids; Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phasmids, phagemids, in-vitro packaging, selection schemes); high-cloning capacity vectors: single stranded DNA vectors (M13, fd, f1); YACs, BACs, PACs, BIBACs, Plant Transformation vectors Ti, Ri plasmids, Binary, Conjugate, selection schemes), Protein Expression Vectors (expression systems for high level protein expression in E.coli and yeast, transcriptional efficiency, inducible promoters, translational efficiency, translational initiation, elongation, codon usage), protein extraction and purification (protein purification tags, histidine and GST tags, IMAC).

Cloning vectors for higher plants:Ti plasmid, Ri Plasmid, Agrobacterium tumefaciens—nature’s smallest genetic engineer,Cloning vectors for animals:Cloning vectors for insects-P elements as cloning vectors for Drosophila.

Unit 4

Genomic DNA libraries (Procedures for Partial, Representative, Enriched, Largeinsert DNA libraries in context to medium and high-capacity cloning vectors) cDNA libraries

(Self-priming methods, replacement synthesis, Okayama and Berg 4 strategy, use of Adapters/Linkers and methylation for directional cloning).

Advance transgenic technology—Inducible expression system—recombinant inducible system—site-specific recombinant system—strategies for gene inactivation—gene inhibition

Genome analysis, genome and beyond: the organization and structure of genome-the organization of nuclear DNA in eukaryotic—mapping and sequencing genome-sequencing genome-comparative genomics—comparative genomics of bacteria-comparative genomics of organelles-comparative genomics of eukaryotes

Large scale mutagenesis and interference: introduction- genome wide gene targeting is the systematic approach to large scale mutagenesis—genome wide random mutagenesis-insertional mutagenesis in invertebrate- Libraries of knock-down phenocopies

Analysis of the transcriptome : introduction- transcriptome- DNA microarray- expression profiling with DNA array

Site Directed Mutagenesis: PCR based methods for site-directed mutagenesis (Single primer methods viz. Mis-incorporation of mismatched oligos, Over-lap extension), whole plasmid single round PCR), mis-repair of mutant oligonucleotides, selection of mutant (dut/ung E. coli strains for SDM through uracil replacement), Ligase chain reaction.

Unit 5

Proteome I- Expression analysis and characterization of proteins: Introduction-protein expression analysis – mRNA Profiling-technologies for protein separation-Mass spectrometry-protein microarray Proteome II-analysis pf protein structure-Introduction-structural analysis and bioinformatics- Proteome III-Protein interactions—introduction-genetic approaches and protein interaction-methods of protein interaction analysis—traditional methods-Library based screening method-systematic analysis of protein complex—Interaction screening and bioinformatics support. Metabolomics and global biochemical:

Application of gene manipulation and genomics: understanding the basis of polygenic disorders and identifying quantitative trait loci—investigating discrete traits in out

breeding populations- Investigating quantitative trait loci (QTLs) in inbred populations-understanding responses to drugs (phamacogenomics)
Application of genetic engineering:

Sequencing Genes and Genomes,Studying Gene Expression and Function-Studying the RNA transcript of a gene,Studying the regulation of gene expression,Identifying control sequences by deletion analysis,Identifying and studying the translation product of a cloned gene, Analysis of proteins by in vitro mutagenesis, Production of Protein from Cloned Genes-Expression vectors, Production of recombinant protein by eukaryotic cells,FlavrSavr tomato, Golden Rice, Bt Cotton, Plantibodies,Plant as the vehicle for molecular farming
Application of recombinant DNA technology: introduction-theme 1-producing useful molecules-theme 2-improving agronomic traits by genetic modification-theme 3 –using genetic modification to study, prevent and cure disease.

Recommended Books

1. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).
2. M. Wink. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology (Wiley, ed. 2, 2011) .
3. K. Wilson, J. Walker. Principles and Techniques of Biochemistry and Molecular Biology (Cambridge University Press, ed. 7, 2010).
4. B. R. Glick., et al. Molecular Biotechnology: Principles & Applications of Recombinant DNA (ASM Press, ed. 4, 2009).
5. M. M. Burell. Enzymes of Molecular Biology (Humana Press, 1993).
6. H.M. Eun. Enzymology. Primer for Recombinant DNA Technology (Academic Press, 1996).
7. Primerose, S.B. and Twyman, R.M.Principles of Gene Manipulations and Genomics. Blackwell Publisher

8. Old, R.W. and Primrose, S. B. 2001. Principles of Gene Manipula-tion: An Introduction to Genetic Engineering 5th Edition. Blackwell Science Ltd., USA.
9. Brown,T. A. Gene Cloning & DNA Analysis. Wiley-Blackwell
10. Kathy Wilson Peacock.Biotechnology and Genetic Engineering. ISBN 978-0-8160-77847
11. Wennacker, Ernst L. 1987. From Genes to Clones: Introduction to Gene Technology. VCH Publishers, Weinheim (Federal Republic of Germany)
12. Watson et al., Molecular Biology of the gene.

Subject Title: Plant Metabolic Engineering

Subject Code: 503

UNIT I

Plant transformation strategies , Stable nuclear transformation , Stable plastid transformation Plant cell-suspension cultures Transient expression systems .Agroinfiltrationmethod,Virus infection method, The magnifection technology , Limitations and optimization of plant production systems, The problem of low yield, Optimizing transcript expression, Optimizing protein's stability , The glycosylation challenge, Choice of suitable host plants , Cost of downstream processing , Overview of plant-derived recombinant proteins , Plant-derived vaccine antigens , Plant-derived antibodies, Therapeutic and nutraceutical proteins Non-pharmaceutical plant-derived proteins

UNIT II

Basic concepts of Metabolic Engineering – Overview of cellular metabolism; Different models for cellular reaction. PRIMARY METABOLITES giving special attention to sugars, amino acids and lipids: The basic structure, The biochemical pathway, Carbon flow, Different regulatory points (regulation at enzyme level and whole cell level, Alteration of feed back regulation, Limiting accumulation of end products), Genetic manipulation of starch, amino acids and oil content in plants and their value addition with significance in horticulture, agriculture and medicine

UNIT III

SEECONDARY METABOLITES giving special emphasis to following components of Flavanoid pathway, Terpenoid pathway, Polyketoid pathway: The basic structure, The biochemical pathway, Carbon flow, Different regulatory points (regulation at enzyme level and whole cell level, Alteration of feed back regulation, Limiting accumulation of end products), Genetic manipulation of flavonoid pathway, Terpenoid and Polyketoid pathways in plants and their value addition with significance in horticulture, agriculture and medicine

UNIT IV

Metabolic Profiling & Transcription Factors for Metabolic Engineering Metabolic Engineering to improve tolerance of plants to abiotic factors/climate change

Metabolic flux - Integration of anabolism and catabolism, metabolic flux distribution analysis bioprocess, material balance, kinetic types, equilibrium reaction. Experimental determination method of flux distribution, metabolic flux analysis and its applications, Metabolic engineering with Bioinformatics, Analysis of metabolic control and the structure, metabolic networks, metabolic pathway synthesis algorithms

UNIT V

Applications of Metabolic Engineering - in pharmaceuticals (edible vaccines, plantibodiesetc), chemical bioprocess, food technology, nutriceuticals, agriculture, biofuels, and biomass conversion. Bioenergy generation, Bioethanol and biohydrogen;

Suggested Reading

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Metabolic Engineering – Principles and Methodologies, 1st Edition, Jens Nielsen Academic Press, 1998
2. Jaiwal P K, Plant Genetic Engineering: Vol 8-9, Metabolic Engineering and Mol Farming (2005), Studium Press. USA
3. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, SpringerVerlag, 1986 4. S. A. Teukolsky, W. T. Vellerling, B. P. Flannery, W. H. Press, Numerical Recipes in C, Cambridge University Press, 1993

Subject Title: Research Methodology, Biosafety & IPR

Subject Code: PBT 504 4Credits

UNIT-I

Introduction to Research Methodology:

Definition of research, classification ofresearch: Fundamental research, Applied research, Descriptive research,Analytical research, Qualitative research, Quantitative research, Conceptualresearch and Empirical research.

Elements of Research:

Research Problem formulation, Problem selecttion,Rationale for defining a research problem, Role of review of literature in definingthe problem, Sources of literature: Primary & secondary sources, treaties,monographs, patents, internet, scientific journals, Critical analysis of existing

literature in the selected research arena, Identification of the research gap, Designing of working research hypothesis.Basic Principles of research design, Ideal attributes of a good design,Conceptsassociated with research design:

Reporting:

Reports, Anatomy & architecture of scientific reports, Classification of reports: techinical reports, thesis, scientific research article, review article.Steps involved in mancuscriptpreparation:Layout, structure and language ofreports: Illustrations, tables ,

bibliography, referencing and footnotes, Thesismanuscript preparation, Making a seminar presentation, Role of effectivecommunication.

Entrepreneurship Concept, definition, structure and theories of entrepreneurshipTypes of start-ups Types of entrepreneurship, environment, process of entrepreneurial development,Entrepreneurial culture, entrepreneurial leadership,Product planning and developmentProject managementSearch for business ideaConcept of projectsProject identification, formulation Design and network analysis Project report and project appraisal

UNIT II

Ethical Issues: Introduction – causes of unethical acts, ignorance of laws, 15L codes, policies and Procedures, recognition, friendship, personal gainsProfessional ethics – professional conductEthical decision making, ethical dilemmasTeaching ethical vaues to scientists, good laboratory practices, good manufacturing practices, laboratory acModuleationBioethics & Society (Indian context): Ethical issues on New Genetics – HumanGenome Project – Gene therapy – Genetic screening – Experimentation with humansubjects -National Practice of health care – Public & Private medical practice – National resource allocations.

UNIT III

EXPERIMENTAL DESIGNS

Objective:-

Design of Experiments provides the statistical tools to get maximum information fromleast amount of resources. This unit is meant to expose the students to the basic principles ofdesign of experiments. The students would also be provided with mathematical background ofvarious basic designs involving one-way and two way elimination of heterogeneity and theircharacterization properties. This Unit would also prepare the students in deriving theexpressions for analysis of experimental data.

Principles of experimental design, precision and accuracy, advantage of replication, experimental

technique. Analysis of variance, fundamental principles of analysis of variance.Criticaldifference, Limitations of the analysis of variance.

Statistical analysis and advantage and disadvantage of basic design-Completely RandomizedDesign, Randomized Block Design, Latin Square Design.

Factorial concept: simple effects, main effects and interaction, Factorial experiments (withoutconfounding), Yates method. Confounding, principles of confounding in a 23 factorialexperiments. Split plot design.

Missing plot technique; Bartlett's techniques for missing plots, cross-overdesign or switch-over

trials, Rotational experiments, progeny selection, compact family block design, uniformity trial,

sire index, sampling in field experiments.

Unit IV

Biosafety

Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment forBiohazards;

Biosafety in the laboratory institution: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety,prudent biosafety practices in the laboratory/ institution Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroadBiotechnology and food safety: The GM-food debate and biosafety assessmentprocedures for biotech foods & related products, including transgenic food crops,case studies of relevance.Ecological safety assessment of recombinant organisms and transgenic crops, case studies of relevance (Eg. Bt cotton). Biosafety assessment of biotech pharmaceutical products such as drugs/vaccines etc. International dimensions in biosafety: Catagena protocol on biosafety, bioterrorismand convention on biological weaponsfor Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs& LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food andagriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Plant Quarantine and Inspection –

Quarantine Rules and Regulations. Biological Diversity Act 2002 and its importance, National biodiversity authority and state biodiversity boards.

UNIT-V

Basics of Intellectual Property Rights (IPRs):

Intellectual property rights (IPR), sovereignty rights, CBD, bioethics and patenting 15L General agreement on trade and tariffs Indian sui-generis system for animal varietyand farmer's rights protection act, PVFRA , WTO with reference to biotechnologicalaffairs, TRIPs. General Introduction: Patent claims, the legal decision – making process, ownershipof tangible and intellectual property, Patent litigation.Basic Requirements of Patentability: Patentable subject matter, novelty and the publicdomain, non obviousness . Special issues in Biotechnology Patents: Disclosure requirements, Collaborative research, Competitive research.Plant biotechnology Indian patents and Foreign patents, Plant variety protection act,The strategy of protecting plants.Recent Developments in Patent System and Patentability of biotechnological inventions.IPR issues in Indian Context Role of patent in pharmaceutical industry, computerrelated innovations. Case studies Rice, Turmeric, Margo, etc. and challenges ahead.

Copyrights & Related Rights,Trademarks, Geographical indications, Licensing and the transfer technology,WIPO: World Intellectual Property Organization, Intellectual Property Rights in India.

References:

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications

6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
7. Satarkar, S.V., 2000. Intellectual property rights and Copy right. EssEss Publications.
8. WIPO Intellectual Property Handbook :WIPO PUBLICATION No. 489 (E) ISBN 978-92-805-1291-5
9. Chakrabarti MC. 1962. Mathematics of Design and Analysis of Experiments. Asia Publ. House.
10. Cochran WG & Cox DR. 1957. Experimental Designs. 2nd Ed. John Wiley.
11. Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
12. Dey A &Mukerjee R. 1999. Fractional Factorial Plans. John Wiley.
13. Dey A 1986. Theory of Block Designs. Wiley Eastern.
14. Hall M Jr. 1986. Combinatorial Theory. John Wiley.
15. John JA &Quenouille MH. 1977. Experiments: Design and Analysis. Charles & Griffin.
16. Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.
17. Khuri AI & Cornell JA. 1996. Response Surface Designs and Analysis. 2nd Ed. Marcel Dekker.
18. Montgomery DC. 2005. Design and Analysis of Experiments. John Wiley.
19. Raghavarao D. 1971. Construction and Combinatorial Problems in Design of Experiments. John Wiley.
20. Chandel S.R.S. A Hand Book of Agricultural Statistics. Kalyani publ.

PBT 551 Practicals based on PBT 501

PBT 552 Practicals based on PBT 502

PBT 553 Practicals based on PBT 503

PBT 554 Practicals based on PBT 504

2nd Year						4th Semester				
Subject Code	Subject Title	Hrs/Week		Exam Hrs	Theory Credits	Practical Credits	Total Credits	Marks		
								External	Internal	Total
PBT 505	Molecular Farming	4	0	3	4	0	4	**80**	**20**	**100**
PBT 506	Plant Functional Genomics	4	0	3	4	0	4	**80**	**20**	**100**
PBT 507	Molecular markers and Breeding	4	0	3	4	0	4	**80**	**20**	**100**
PBT 508	Project and Research Paper writing	0	8	3	0	8	**8**	**200**	**00**	**200**
PBT 555	Practical Based on 505	0	4	3	0	2	**2**	**50**	**00**	**50**
PBT 556	Practical based on 506	0	4	3	0	2	**2**	**50**	**00**	**50**
PBT 557	Practical Based on 507	0	4	3	0	2	**2**	**50**	**00**	**50**
					12	**14**	**26**	**590**	**60**	**650**

Subject Title: Molecular Farming

Subject Code: PBT 505 4 Credits

Subject Title: Plant Functional Genomics

Subject Code: PBT 506 4 Credits

Unit 1

Definition and origin of plant functional genomics, Role of Model plant Species-Introduction, History, genomics, tools and databases for Arabidopsis and Rice, evolutionary divergence and utility of Model Species, Examples of comparative biology illustrate the utility of model species and extent of conservation of genetic network during evolution, Prediction of QTLs from model species

Full lengthcDNAs for the discovery and annotation of genes in *Arabidopsis thaliana*- collection of Arabidopsis full length cDNAs, application of full length cDNAs to genome annotation & functional analysis

T-DNA mutagenesis: from tagging to insertion sequence database, crown Galls, Neoplasia and Agrobacterium, development of transformation protocol

Novel reverse genetics tools in Plant functional Genomics, Transcriptomics in Plants-from Expression to gene function, metabolite profiling in Plants, Large scale yeast Tow-Hybrid analysis

Unit 2

Genetic maps and use of synteny-genetic mapping, synteny, comparative mapping, insilico experimental method, Simple TAE-Based method to generate large insert BAC libraries from plant species, transcript profiling and expression level mapping, methods for functional proteomic analyses, stab \\le transformation of plants, transient transformation of plants

Bridging the gene to function knowledge Gap through functional genomics, Heterologous and cell free protein expression systems, functional genomics and structural biology in the definition of gene function, in situ analysis of gene expression in plants, plant and crop databases, plant genome annotation methods, molecular Plant breeding –methodology and achievements, practical delivery of genes to the marketplace, ecological genomics of natural plants population –the Indian perspective

Unit 3

Functional genomics of a C*yanobacteriumsynechocystis* sp. PCC 6803-gene disruption- transcriptional analysis-proteome analysis-genome database, Chlamydomonas Genome-new approaches for a classical model system-chloroplast- mitochondria- nuclear and functional genome, Functional genomic in Physcomitrella, Arabidopsis functional genomics tools-curriculum vitae of a model-functional genomics tools-tools for reverse genetics, forward screening and studying mechanisms

Rice functional genomics—from nucleotide sequence to gene function-functional genomics based on forward genetics-reverse genetics and activation tagging, Maize genomics-Maize as a crop-genome size-genome expansion-clone maps-genetics map-gene tagging-gene enrichment procedures-ESTs-microarray

Prospects for functional genomics in a new model grass- why a new grass model?- understanding the plant –genome and toward functional genomics of pathogenic interactions

Unit 4

Chloroplast proteomics-the dynamics nature of the plastid and its proteome, prediction of the plastid proteome-prediction of proteomes nonphotosynthetic plastids, systematic experimental identification and characterization of the plastid proteome, posttranslational modification of the chloroplast proteome—Plastid-localized protein complex and protein-protein interactions

Plant Mitochondrial proteomics-technology issue, science issue and future direction, Functional characterization of the photosynthetic apparatus in Arabidopsis thaliana-introduction-overview of electron transport-photosystem II –cytochrome b/f complex, photosystem I- accessory electron transport systems--elements involved in nonphotochemical quenching- the ATP synthase, Functional genomics of plant nitrogen metabolism- functional genomics of nitrate transport Arabidopsis- transcriptome analysis in relation to variation in nitrogen supply

Unit 5

Functional genomics of Plant salinity tolerance: salinity tolerance in context problems plants face in high salinity- genomic tool kit applied to salinity stress research- mutants and mutant phenotypes in salinity stress tolerance- ESTs and cDNAs from salt stressed plants- salinity induced changes of the transcriptome- salinity dependent signal transduction- salinity stress engineering

Functional genomics applied to plant fatty acid biosynthesis- directed gene discovery-large scale DNA sequencing and gene-expression analysis

Genetic and molecular control of seed development in Arabidopsis- from genetic to molecular bases of seed development –ovule development-endosperm development-embryogenesis-limitation of the genetics approach and new prospects

Plant transporter: identification of novel transporters by Heterologous expression-gene expression-Subcellular localization – protein interaction-analysis of loss-of-function “KNOCKOUT” mutants and “KNOCKDOWN” mutants-the ARAMEMNON database-connecting Arabidopsis functional genomics resource with crop plant research

Functional genomics of the Cytochrome P450 Gene super family n Arabidopsis thaliana-cytochrome P450-comparative genome analysis-small proportion of the Arabidopsis P450s have been assigned specific cellular function-a variety of new methods are becoming increasingly available to assign function to P450 family members

Functional genomics of protein phophorylation in Arabidopsis thaliana-protein kinase and phosphatase Encoded in the Arabidopsis Genome-Histidine kinase and the two-component signaling

Subject Title: Molecular markers and Breeding

Subject Code: PBT 507 4 Credits

Course objectives:

To introduce current status of research underpinning plant genome analysis .

To integrate the abstractions of genetics with molecular biology phenomenon .

To provide a comparative account of diverse genotyping tools applied in molecular breeding, taxonomy, conservation genetics, gene flow and quantitative genetics.

Unit I

Genome Organization:Organellar genome and Nuclear Genome: Unique sequences, Repeat DNA sequences, Classification of Repeat DNA (Tandem repeats, Interspersed repeats, Micro-satellites, Mini-satellites, midi-satellites, VNTRs)

The dynamic genome: Polymorphisms and Sources of Genetic variation

Unit II

Oveview of Genetic Markers: Phenotypic Markers, Biochemicalmarkers, DNA based markersMolecular marker and DNA fingerprinting techniques:Concepts, classification and methodologies: Hybridization based markers (viz. Restriction Fragment Length Polymorphism, Oligonucleotide fingerprinting), PCR based markers (viz. DNA Amplification Fingerprinting, Arbitrarily Primed PCR, Randomly Amplified Polymorphic DNA, SSRs, STMS, SCARs, Inter-SSRs, Multiple Arbitrary Amplicon Profiling, Amplified Fragment Length Polymorphism, Selectively Amplified Microsatellite Polymorphic Loci, Inter retrotransposon amplified polymorphism, retrotransposon-microsatellite amplified polymorphism, Diversity Array Technology (DArTs), SNPs and SNP based assays for high-throughput genotyping, EST based markers, Sequencing by Hybridization (SBH)

Unit III

Molecular Markers and Assessment of genetic diversity:

Principles of Numerical taxonomy, binary matrix to pheneticdendograms, Structure analysis, Case Studies and examples

Molecular Markers for genome mapping:

Principles of Genetics: Laws of inheritance, Linkage and crossing-over, Recombination analysisGenotyping Concepts for Genetic mappingConstruction of genetic linkage maps

for gene and QTL mapping, positional cloning for gene identification, Introduction to linkage mapping software packages and interfaces

Breeding by design: Marker Assisted Selection (MAS), gene introgression and pyramiding, BSAGenotyping for Physical mapping:Fingerprinting for BAC assembly

Unit IV

Types of Mapping populations in Plants: F2 populations, RILs (recombinant inbred lines), Backcross lines, NILS (Near Isogenic Lines), HIF (Heterogenous Inbred Families), AILs (Advanced Intercross Lines)

Unit V

Other Application of Molecular Markers: Genotyping tools as plant variety protection, hybrid purity tests, diagnostics (transgenics, forensics)

Other Mapping tools and Methodologies: Introduction to Cytogenetic maps, Radiation Hybrid Maps, HAPPY mapping, Physical Maps, Comparative/Synteny mapping

Suggested Readings:

1. Weising K, Nybom H, Wolff K, Meyer W (1995) DNA fingerprinting in plants an fungi. CRC Press, Boca Raton, Florida
2. Kole C (2007) Genome mapping and molecular breeding in plants. Springer Verlag, Berlin
3. H John Newbury (2003) Plant Molecular Breeding. CRC Press, US
4. Kole C and Abott AG (2008) Molecular breeding: principles and practices of plant genomics. Science Publishers, US
5. Griffiths AF, Miller JH, Suzuki DT, Lewontin RC, Gelbart WM (2000) An introduction to genetic analysis. WH Freeman & Co, US
6. Vos P, Hogers R, Bleeker M, Reijans M, van de Lee T, Hornes M, Frijters A, Plot J, Peleman J, Kuiper M, Zabeau M (1995) AFLP: a new technique for DNA fingerprinting. Nucl Acids Res 23: 4407-4414
7. Peleman JD and van der Voort JR (2003) Breeding by design. Trends in Plant Science. 8: 330-339.

8. Collard BCY, Jahufer MZZ, Brouwer JB and Pang ECK (2005) An introduction to markers, quantitative trait loci (QTL) mapping and marker assisted selection for crop improvement: The basic concepts. Euphytica 142: 169-196
9. Varshney RK, Hoisington DA, Nayak S, Graner A (2009) Molecular Plant Breeding: methodology and achievements, In: Methods in Molecular Biology, Plant Genomics, vol. 513 (eds. Daryl J. Somers et al.), Humana Press, a part of Springer Science + Business Media, New York, NY; Book doi: 10.1007/978-1-59745- 427-8_15
10. Varshney RK, Tuberosa R (2008) Genomics Assisted Crop Improvement, Vol I: Genomics Approaches and Platforms, Springer, The Netherlands
11. Varshney RK, Tuberosa R (2008) Genomics Assisted Crop Improvement, Vol II:

Genomics Applications in Crops, Springer, The Netherlands

Subject Title: Project and Research Paper writing

Subject Code: PBT 508

PBT 555Practical Based on 505

PBT 556Practical based on 506

PBT 557Practical Based on 507

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