INDEX
Department of Botany
SEMESTER -VI

BSC. (HONS.) BOTANY
Category-I
Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE - 16: Plant Biotechnology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Biotechnology **DSC-16**	4	**2**	**0**	**2**	Class XII Pass	Nil

Learning objective:

- to provide knowledge of techniques used in plant biotechnology and their application.

Learning outcomes: At the end of the course the students will be able to:

- understand basic concepts, principles and methods in plant biotechnology.
- explain the use of acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.

Unit 1: Introduction to Biotechnology **02 Hours**

Historical timeline; sectors of Biotechnology, brief overview of techniques and methods in Biotechnology.

Unit 2: Plant Tissue Culture **08 Hours**

Historical perspective (Major contributions of Haberlandt, Laibach, White, Reinert and Steward, Murashige and Skoog, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); types and composition of media: roles of nutrients (major and minor), vitamins, hormones and others (coconut water, activated charcoal); plasticity and totipotency; regeneration: organogenesis (direct and indirect) and embryogenesis (somatic and zygotic); protoplast isolation, culture and fusion; tissue culture applications (micropropagation, androgenesis, haploids, triploids, cybrids, production of virus-free plants).

Unit 3: Recombinant DNA technology **07 Hours**

Restriction Endonucleases (History, Types I - IV, biological roles and applications); modifying enzymes and their applications (nucleases, ligases, alkaline phosphatase, polynucleotide kinase), introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC18, pUC19, BACs, Lambda phage, YACs. Gene Cloning: Restriction digestion of DNA, elution of DNA from agarose gels, ligation, bacterial transformation and selection of recombinant clones (alpha complementation, antibiotic selection, restriction enzyme based selection)

Unit 4: Genetic transformation of Plants **05 Hours**

Methods of gene transfer to plants: *Agrobacterium*-mediated transformation (Ti plasmids, development of binary vectors), Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; selection of transgenic plants: selectable marker genes (Positive selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP); Introduction to genome editing.

Unit 5: Applications **08 Hours**

Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready™ soybean); Transgenic crops with improved quality traits (Flavr Savr™ tomato. Golden™ rice); Improved horticultural varieties (Moondust carnations); Bioremediation (Superbug); Edible vaccines; Biosafety of transgenic plants.

Practicals **60 hours**

1. Preparation of Murashige & Skoog's (MS) medium.
2. Initiation of axenic cultures- seed sterilisation and inoculation
3. Micropropagation (shoot induction) using leaf and/or nodal explants of tobacco/*Datura*/ *Brassica* etc.
4. Study of anther culture, embryo and endosperm culture, somatic embryogenesis using digital resources.
5. Preparation of artificial seeds.
6. Induction of callus and analysis of effects of growth regulators (Auxin and Cytokinin) on *in vitro* regeneration using tobacco leaf explant.
7. Preparation of chemically competent cells of *E. coli*.
8. Transformation of *E. coli* with plasmid DNA by heat shock method.
9. Restriction digestion and gel electrophoresis of plasmid DNA.
10. Construction of restriction map of circular and linear DNA from the data provided.
11. Visit to a research laboratory.

Suggested Readings:

1. Slater, A., Scott, N. W. & Fowler, M. R. (2010) Plant Biotechnology: The Genetic Manipulation of Plants. 2nd edn. New York, USA: Oxford University Press Inc.
2. Snustad, D.P., Simmons, M.J. (2010) Principles of Genetics, 5th edition. Chichester, England: John Wiley and Sons.
3. Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8th edn. UK: Wiley Blackwell.
4. Primrose, S. B. & Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7th edn. Victoria, Australia: Blackwell Publishing.
5. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.

Additional Resources:

1. Bhojwani, S.S. and Dantu, P.K. (2013). Plant Tissue Culture: An Introductory Text. Springer New Delhi Heidelberg New York Dordrecht London
2. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6th edn. Washington, U.S.: ASM Press.

3. Bhojwani, S.S., Bhatnagar, S.P. (2011). The Embryology of Angiosperms, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
4. Stewart, C.N. Jr. (2008). Plant Biotechnology and Genetics: Principles, Techniques and Applications. New Jersey, U.S.: John Wiley & Sons Inc.
5. Glick, B.R., Pasternak, J. J. & Patten C. (2010). Molecular Biotechnology: Principles and Applications. 4th edn. Washington, U.S.: ASM Press.
6. Glick, B.R., & Patten C. (2017). Molecular Biotechnology: Principles and Applications. 5th edn. Washington, U.S.: ASM Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17: Plant Biochemistry and Metabolism

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Biochemistry and Metabolism **DSC - 17**	**4**	**2**	**0**	**2**	Class XII Pass	**Nil**

Learning Objectives:

- To understand different pathways of metabolism in plant cells.
- To understand how various metabolic pathways work in a synchronized manner.

Learning Outcomes: At the end of the course the student will:

- know the details of carbon assimilation, oxidation, synthesis of ATP- the energy currency of the cell, nitrogen fixation and lipid metabolism.
- understand the role of enzymes in regulating metabolic pathways for molecules like carbohydrates, lipids and proteins.
- understand the coordination of various biochemical reactions with reference to cell requirement and its economy.

Unit 1: Concepts in Metabolism **01 Hour**

Introduction, anabolic and catabolic pathways, coupled reactions

Unit 2: **Enzymes** **04 Hours**

Structure, classification and mechanism of action, Michaelis-Menten equation (no derivation), enzyme inhibition (competitive, non-competitive and uncompetitive), allosteric regulation and covalent modulation, factors affecting enzyme activity.

Unit 3: Carbon Assimilation **07 Hours**

Concept of light, absorption and action spectra, photosynthetic pigments (no structural details), PSI, PSII antenna molecules and reaction centres, LHC, photochemical reaction, photosynthetic electron transport, photophosphorylation (cyclic and non-cyclic)

Dark reactions: CO_2 reduction in C3, C4 pathways and CAM, photorespiration

Unit 4: Carbohydrate Metabolism **02 Hours**

Metabolite pool and exchange of metabolites, synthesis and degradation of sucrose and starch (no structural details)

Unit 5: Carbon Oxidation **06 Hours**

Glycolysis, fate of pyruvate- aerobic, anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, Krebs cycle and its regulation, amphibolic role of Krebs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration

Unit 6: ATP Synthesis **02 Hours**

Mechanism of ATP synthesis-substrate level phosphorylation, oxidative and photophosphorylation, chemiosmosis, ATP synthase

Unit 7: Lipid Metabolism **04 Hours**

Triglycerides: synthesis, degradation through alpha and beta -oxidation, glyoxylate cycle

Unit 8: **Nitrogen Metabolism** **04 Hours**

Nitrate assimilation (NR and NiR), biological nitrogen fixation in legumes (nodulation and role of dinitrogenase) Ammonia assimilation: GS-GOGAT, reductive amination and transamination.

Practicals **60 Hours**

1. Study the activity of urease and the effect of substrate concentration on its activity.
2. Study the effect of pH on the activity of catalase enzyme.
3. Chemical separation of photosynthetic pigments (liquid-liquid partitioning).
7. Study Hill reaction by dye reduction method.
8. Study the law of limiting factors.
9. Compare the rate of respiration in three different parts of a plant.
10. Study the activity of Nitrate reductase in leaves of two different plants.
11. To study the activity of lipases in germinating oil seeds and explain mobilization of lipids during germination.
12. To study the fluorescence in isolated chlorophyll pigments.
13. To study the absorption spectrum of photosynthetic pigments.
14. To study respiratory quotient (RQ).

Suggested Readings:

1. Nelson, D.L., Cox, M.M. (2017). Lehninger Principle of Biochemistry, 7th edition. NewYork, NY: W.H. Freeman, Macmillan learning.
2. Taiz, L., Zeiger, E., Moller, I. M. & Murphy, A. 2018. Plant Physiology and Development, International 6th edn, Oxford University Press, Sinauer Associates, New York, USA.

3. Hopkins, W.G., Huner, N. (2008). Introduction of Plant Physiology, 4th edition. New Jearsey, U.S.: John Wiley and sons.
4. Jones, R., Ougham, H., Thomas, H., Waaland, S. (2013). The molecular life of plants. Chichester, England: Wiley-Blackwell.

Additional Resources:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants, 2nd edition. New Jearsey, U.S.: Wiley Blackwell.
2. Kochhar, S.L. & Gujral, S.K. 2020. Plant Physiology: Theory and Applications, 2nd Edition. Cambridge University Press, UK.
3. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 18: Advanced tools & Analytical Techniques in Plant Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced tools & Analytical Techniques in Plant Biology **DSC- 18**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

- To gain the knowledge on various techniques and instruments used for the study of plant biology

Learning Outcomes: At the end of this course, students will be:

- competent in the basic principles of major techniques used in study of plants
- understand principles and uses of light, confocal, transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit 1: Imaging and related techniques **06 Hours**

Electron microscopy: Transmission and Scanning electron microscopy, cryofixation, negative staining, shadow casting, freeze-fracture, freeze-etching; Chromosome banding, FISH, GISH, chromosome painting.

Unit 2: Fractionation methods **04 Hours**

Centrifugation: types of rotors, differential and density gradient centrifugation, sucrose density gradient, ultracentrifugation, caesium chloride gradient; marker enzymes for analysis of cellular fractions.

Unit 3: Radioisotopes **04 Hours**

Types of radioisotopes; types of emissions (alpha, beta, gamma radiations); half-life; use of radioisotopes in biological research; auto-radiography; pulse-chase experiment; Biosafety measures and disposal of radioactive material

Unit 4: Spectrophotometry **02 Hours**

Principles and applications of UV, Visible and IR spectrophotometry

Unit 5: Chromatography **05 Hours**

Principles and applications of Paper chromatography, Column chromatography, TLC, GLC,

HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.

Unit 6: Techniques for detection and analysis of nucleic acids and proteins 09 Hours

PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.

Practicals 60 hours

1. Study of microscopic techniques using digital resources (freeze-fracture, freeze-etching, negative staining, FISH, chromosome banding).
2. Isolation of chloroplasts by differential centrifugation.
3. Separation of nitrogenous bases by paper chromatography.
4. Separation of sugars by thin layer chromatography
5. Separation of chloroplast pigments by column chromatography (demonstration)
6. Amplification of DNA by PCR and visualization of PCR products.
7. Detection of DNA polymorphism (SSR based DNA fingerprinting).
8. Gel based and capillary based DNA sequence data analysis.
9. Estimation of protein concentration by Bradford method.
10. PAGE to study overexpression of proteins/ Separation of proteins by PAGE.
11. Blotting techniques: Southern, Northern and Western using digital resources.

Suggested Reading:

1. Hofmann, A., & Clokie, S. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press.
2. Gerald Karp, Janet Iwasa, Wallace Marshall (2019).Karp's Cell and Molecular Biology, 9th Edition: Wiley
3. O' Brien, T.P. and Cully M.E (1981). The Study of Plant Structure. Principles and selected Methods, Termarcarphi Pty. Ltd., Melbourne.

Additional Resources:

1. Cooper, G.M., Hausman, R .E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE -07): Recombinant DNA Technology and Proteomics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Recombinant DNA Technology and Proteomics BOT-DSE-07	**4**	**2**	**0**	**2**	Class XII Pass	**Nil**

Learning Objectives: This course structure is designed to:

- familiarize the students with the essential knowledge and technical skills/ methodology involved in creating recombinant DNA molecules.
- provide knowledge on generating modified organisms, synthesize a product or modify a biological process by tailoring and/or incorporating DNA from one organism into another.

Learning outcomes:

After completion of the course students will:

- be able to identify, locate, isolate and functionally characterize DNA sequences/genes.
- Get familiarized with technologies used to create recombinant DNA.
- be able to design strategies adopted to generate genetically modified organisms for various applications.
- be aware of the application of recombinant DNA in pharmaceuticals, agriculture, environment management, etc.

Unit 1: **Enzymes in recombinant DNA technology** **04 hours**

Nucleases: DNAses, RNAses, Restriction endonucleases (discovery, classification, isoschizomers and cleavage action), exonucleases, polymerases (DNA, RNA, Reverse transcriptase, *Taq* polymerase), ligases, kinases, alkaline phosphatase.

Unit 2: Cloning vectors **04 hours**

Plasmids (basic features and types - pBR322, pUC18, pUC19, TA vectors), lambda vectors (insertion and replacement vectors), M13, cosmids and phagemids, pBluescript II; Artificial

chromosomes as vectors (BACs, YACs). Expression vectors and shuttle vectors, YeP; strategies for over-expression of proteins

Unit 3: Isolation and cloning of target DNA **03 hours**

PCR, Strategies: isolation/generation of target sequence (restriction-based and PCR-based), generation of compatible cohesive ends, linkers and adaptors.

Unit 4: **Creating and screening DNA libraries** **03 hours**

Construction of genomic and cDNA libraries, screening and identification of target sequence by DNA hybridization and immunological methods.

Unit 5: **Introduction of DNA into host cell** **06 hours**

Preparation and transformation of competent bacterial cells (heat shock and electroporation). DNA delivery into plant cells and protoplasts: *Agrobacterium* mediated (disarmed Ti plasmid), electroporation, microinjection, liposomes and biolistic methods). Selection and identification of transformants (alpha-complementation, antibiotic resistance and reporter genes (GUS and GFP).

Unit 6: Protein purification and Identification **03 hours**

Chromatography-based methods (ion exchange chromatography and affinity chromatography), antibody-based methods (ELISA and Western blotting).

Unit 7: **Proteomics** **04 hours**

Introduction to proteomics: gel-based methods (Native and SDS PAGE, 2D gel electrophoresis, differential gel electrophoresis), mass spectrometry.

Unit 8: Applications **03 hours**

Application of recombinant DNA technology and Proteomics in medicines (insulin, vaccines), agriculture (insecticide delta endotoxin, golden rice, antisense strategy in tomatoes).

Practicals **60 hours**

1. Plasmid DNA isolation using Bacterial cultures.
2. Agarose Gel electrophoresis of plasmid DNA
3. Quantification of DNA by spectrophotometry
4. Extraction of protein and its Quantification by Lowry's method
5. Constructing Restriction map of linear and circular DNA using the data provided

6. Study of recombinant DNA techniques through photographs (Biolistic technique, electroporation, microinjection, PCR, western blotting, artificial chromosomes YAC, BAC, Cosmid, Phagemid, Ti plasmid)
7. Demonstration of SDS-PAGE and affinity Chromatography

Suggested reading:

1. Brown, T. A. (2016) Gene Cloning an Introduction: Chapman & Hall.
2. Zlatanova, J. and Van Holde, K.E. (2016) Molecular Biology Structure and Dynamics of Genomes and Proteomes: Taylor and Francis; .
3. Glick, Bernard R, Jack J. Pasternak, Patten Cheryl L. 2018. Molecular Biotechnology; principles and applications of recombinant DNA, ASM Press, Washington.
4. Lovric, J., 2011. Introducing Proteomics. Wiley-Blackwell
5. S.B. Primrose, R. M. Twyman, R.W.Old. 2001. Principles of Gene manipulation: Blackwell Science; 2001

Additional reading:

1. Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
2. Kreuzer, H. Massey, A (1996) Recombinant DNA and Biotechnology; A guide for teachers; ASM Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines
(B.Sc. Programmes with Botany as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE (DSC-6.): Economic Botany and Biotechnology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Economic Botany and Biotechnology LS-DSC-BOT - 6	**4**	**2**	**0**	**2**	Class XII Pass	**Nil**

Learning Objectives:

- To understand the economic importance of plants as cash crops - cereals, legumes, spices, non-alcoholic beverages, oils and fibres.
- To understand the concepts and applications of the techniques of Plant Tissue Culture and Recombinant DNA Technology in enhancing economic value of plants

Learning Outcomes: At the end of the course the students will have:

- knowledge of the nutritive and commercial / medicinal value of various plants and plant parts used as sources of carbohydrates, proteins, spices, oil and beverages.
- practice the methods / techniques of Plant Tissue Culture and apply tools of Biotechnology in improvement of crops for economic potential.

Unit 1: Origin of Cultivated Plants **02 hours**
Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2: Cereals and millets **04 hours**
Wheat, Rice and Maize: Origin, description of the part used, economic importance. Major and minor millets (Pearl millet, Sorghum, Kodo millet and Finger millet).

Unit 3: Pulse crops **02 Hours**
General account and economic importance with special reference to chickpea and pigeon pea.

Unit 4: Spices **03 Hours**

General account, part used and economic importance with special reference to cardamom, clove and black pepper.

Unit 5: Beverage **02 Hours**

Tea; morphology, types, processing, uses.

Unit 6: Oils and Fats **02 Hours**

General account; Classification, Difference between essential oils and fatty oils, uses (Sunflower, Soybean, Mint)

Unit 7: Fibre Yielding Plants **02 Hours**

Classification of fibres. Cotton and Jute, description of part used and uses.

Unit 8: Plant Tissue Culture Technology **05 Hours**

Introduction; nutrient media; aseptic and culture conditions, organogenesis (direct and indirect) and somatic embryogenesis; androgenesis, embryo culture, endosperm culture, protoplast culture Applications: micropropagation, generation of somaclonal variants, synthetic seeds and germplasm conservation.

Unit 9: DNA Recombinant Technology **08 Hours**

Introduction, Blotting techniques (Southern and Northern); PCR; Molecular DNA markers (RAPD, RFLP) and DNA fingerprinting in plants. Genetic Engineering Techniques: Gene cloning vectors (pUC18, Ti plasmid); enzymes (nuclease, polymerase, kinase, ligase); screening for gene of interest by DNA probe hybridisation, Insertion of genes into plant (*Agrobacterium* mediated, biolistics); selection of recombinants by selectable marker and reporter genes (GUS). Applications: Bt cotton, Golden rice, Flavr-Savr tomato, Edible vaccines.

Practicals: **60 Hours**

1. Study of economically important plants through: specimens (Millets, Pigeon pea, Chickpea, Tea, and Cotton), Sections (Wheat, Maize, Black pepper, Clove), Micro-chemical Tests (Wheat, Soybean, Groundnut and Cotton).
2. Principle and working of equipment used in Tissue culture: Laminar air flow cabinet, Autoclave.
3. Preparation of culture medium (MS medium), sterilisation and inoculation of explants (Demonstration)
4. Study of Micropropagation, Anther culture, Somatic embryogenesis, Endosperm and Embryo culture
5. Study of Molecular techniques: PCR, Blotting techniques
8. Extraction and separation of DNA.
9. Visit to any tissue culture/biotechnology laboratory

Suggested reading:

1. Bhojwani, S.S., Razdan, M.K. (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.
2. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text. Springer

3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications. Washington, U.S.: ASM Press.
4. Kochhar, S.L. (2011). Economic Botany in the Tropics, 4th edition. New Delhi, Delhi: MacMillan Publishers India Ltd.
5. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, Springer
6. Wickens, G.E. (2012) Economic Botany: Principles and Practices. Springer

Additional Resources:

1. Park, S. (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition. Elsevier
2. Ranabhatt, H. and Kapor, R. (2018). Plant Biotechnology {Woodhead Publishing}
3. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition {CBS / Oxford & IBH}
4. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}.
5. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 3rd Edition {Wiley-Blackwell}
6. Trigiano, R. N., Dannis, J. Gray (2019). Plant Tissue Culture, Development, and Biotechnology {CRC Press}

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC 06)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Biotechnology: Concepts and Applications ALS BOT DSC 06	**4**	**2**	**0**	**2**	**Appeared in semester V**	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to give students knowledge of techniques used in plant biotechnology and its applications.
- to explore the use of biotechnology to generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
- to understand the biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals, food industry, agriculture, horticultural and ecology. This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
- to perform the techniques currently used to generate information and detect genetic variation.

Learning Outcomes:

By studying this course, students will be able to:

- comprehend the basic concepts, principles and processes of plant biotechnology.

- apply the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural fields.
- use the basic biotechnological techniques to explore molecular biology of plants.
- explain the use of biotechnological techniques for plant improvement and biosafety concerns.

Unit 1: Introduction to Biotechnology (2 Hours)

Historical timeline; Brief overview of techniques and methods in Biotechnology, sectors of Biotechnology.

Unit 2: Plant Tissue Culture (8 Hours)

Historical perspective (Haberlandt, Laibach, White, Reinert and Steward, Murashige, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); Composition of media; Nutrients (major and minor), vitamins and hormones; Plasticity and Totipotency; Regeneration: Organogenesis (Direct and Indirect) and Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, haploids, triploids, cybrids, production of virus-free plants).

Unit 3: Recombinant DNA Technology and Genetic Transformation (12 Hours)

Restriction Endonucleases (History, Types I - IV, biological role and applications); Modifying enzymes and their applications (nucleases, ligases, alkaline phosphatase, polynucleotide kinase) Introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC 18, pUC19, BACs, Lambda phage, YACs. Gene Cloning: Restriction digestion of DNA, ligation, bacterial transformation and selection of recombinant clones; Methods of gene transfer to plants: *Agrobacterium*-mediated transformation (Ti plasmids), Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenic plants: selectable marker genes (Positive

selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP).

Unit 3: Applications of Transgenic Technology (8 Hours)

Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Edible vaccines; Introduction to genome editing; Biosafety of transgenic plants.

PRACTICALS 60 hours

1. Preparation of nutrient media for plant cell cultures- Murashige & Skoog's (MS) medium and B5 medium.
2. Initiation of axenic cultures (seed sterilisation and inoculation)
3. Micropropagation (shoot induction) using leaf and/or nodal explants of tobacco/*Datura*/ *Brassica* etc.
4. Study of anther culture, embryo and endosperm culture, somatic embryogenesis using digital resources/ photographs.
5. Preparation of artificial seeds.
6. Isolation of plasmid DNA.
7. Induction of callus and analysis of effects of growth regulators on *in vitro* regeneration using tobacco as a model plant
8. Preparation of competent cells and transformation of *E. coli* by heat shock method.
9. Restriction digestion and gel electrophoresis of plasmid DNA.
10. Construction of restriction map of circular and linear DNA from the data provided.
11. Visit to a Research laboratory.

Essential/recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). The Embryology of Angiosperms, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.
3. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6th edn. Washington, U.S.: ASM Press.

4. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8th edn. UK: Wiley Blackwell.
5. Slater, A., Scott, N. W. & Fowler, M. R. (2010) Plant Biotechnology: The Genetic Manipulation of Plants. 2nd edn. New York, USA: Oxford University Press Inc.
6. Primrose, S. B. and Twyman, R.M. (2013) Principles of Gene Manipulation and Genomics. 7th edn. Wiley-Blackwell Publishing.

Suggested Readings :

1. Stewart, C.N. Jr. (2008). Plant Biotechnology and Genetics: Principles, Techniques and Applications. New Jersey, U.S.: John Wiley & Sons Inc.
2. Snustad, D.P., Simmons, M.J. (2010). Principles of Genetics, 5th edition. Chichester, England: John Wiley and Sons.
3. Bhojwani, S.S. and Dantu, P.K. (2013). Plant Tissue Culture: An Introductory Text. Springer New Delhi Heidelberg New York Dordrecht London

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DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Systematics ALS BOT DSE 04	4	2	0	2	Appeared in semester V	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to gain knowledge about the basics of plant systematics.
- to get an insight into the interrelationships of plant systematics and allied subjects.

Learning Outcomes:

By studying this course, students will be able to:

- understand technical terminology used in plant taxonomy.
- apply the terminologies to describe, identify and classify the flowering plants.
- search and analyze taxonomic information from internet-based scientific databases and other resources.
- comprehend and compare various systems of classification.
- recognize diversity in local/regional flora.

Unit 1: Introduction (1 Hour)

Plant identification, Classification, Nomenclature, Biosystematics.

Unit 2: Identification (4 Hours)

Field inventory, Herbarium Techniques, Functions of Herbarium, Important herbaria and botanical gardens of the world and India, Virtual Herbarium, E-flora: Flora, Monographs, Journals.

Unit 3: Systematics-An Interdisciplinary Science (5 Hours)

Evidence from cytology, phytochemistry [Alkaloids, Phenolics, Glycosides, (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4: Taxonomic Hierarchy (2 Hours)

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological & evolutionary)

Unit 5: Botanical Nomenclature (7 Hours)

Principles and rules (ICN); Ranks and names; Typification, Author citation, Valid publication, Rejection of names, Principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit 6: Basic Terms and Concepts of Phylogeny (4 Hours)

Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades and grades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram).

Unit 7: Systems of Classification (7 Hours)

Major contributions of Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Cronquist, Bremer and MW Chase; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV) Classification (major clades).

PRACTICAL (60 Hours)

1. To prepare at least 2 herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level (according to Bentham and Hooker's classification).

2. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification.

Note: Any twelve families from the following list to be studied with at least two specimens (or one where limitations exist).

List of Suggested Families (*mandatory)

Acanthaceae, Rubiaceae, *Apiaceae, Apocynaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, Liliaceae, *Malvaceae, Moraceae, *Poaceae, *Ranunculaceae, *Solanaceae.

Essential/recommended readings:

1. Simpson, M. G. (2019). *Plant systematics*. 3rd Edition, Academic press.
2. Singh, G. (2019). *Plant Systematics- An Integrated Approach.* 4th edition. CRC Press, Taylor and Francis Group.
3. Pandey, A. K., Kasana, S. (2021). *Plant Systematics*. 2nd Edition. CRC Press Taylor and Francis Group
4. *http://www.mobot.org/MOBOT/research/APweb/*
5. Maheshwari, J. K. (1963). *The flora of Delhi.* Council of Scientific & Industrial Research.

6. Maheshwari, J. K. (1966). *Illustrations to the Flora of Delhi.* Council of Scientific & Industrial Research.
7. Harris, J. G., Harris, M. W. (2001). *Plant Identification Terminology: An Illustrated Glossary.* Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.

Suggestive Readings:

1. The Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J.M, Fay M.F., Byng, J.W., Judd, W.S., Soltis, D.E., Mabberley, D.J., Sennikov, A.N., Soltis, P.S., Stevens, P.F. (2016). *An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV.* Botanical journal of the Linnean Society 181 (1): 1-20.
2. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif
3. https://www.digitalatlasofancientlife.org
4. http://apps.kew.org/herbcat/navigator.do
5. https://efloraofindia.com/
6. https://powo.science.kew.org/
7. Page, R.D.M., Holmes, E.C. (1998). *Molecular Evolution: A Phylogenetic Approach*. Blackwell Publishing Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE (BOT-GE-20)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Genomics, Proteomics and Metabolomics **BOT-GE-20**	4	2	0	2	Class XII Pass	**Nil**

Learning Objectives:

- Build the concepts of genomics, proteomics and metabolomics.
- Understand the role of model organisms in genomics studies
- Familiarization of tools used in genomics and proteomics.

Learning Outcomes: At the end of this course, students will be able to:

- understand the implications of genomic, transcriptomic, proteomic and metabolomic studies in an organism.
- assimilate logic and reasoning behind choice of model organisms for genomics study.

Unit 1: Introduction to genomics **02 Hours**

Recapitulating basics of prokaryotic and eukaryotic genomes; basic concept of structural and functional genomics.

Unit 2: Model organisms in genomics **02 Hours**

Features of important model organisms used in genomics study (*Escherichia coli*, *Saccharomyces cerevisiae*, *Caenorhabditis elegans*, *Arabidopsis thaliana*)

Unit 3: Sequencing strategies **04 Hours**

Sequencing: basic principle-Sanger's method; classical approaches for sequencing large genomes (whole genome shot gun method viz. WGS, clone by clone sequencing); Next generation sequencing (NGS) ; Concept of third generation sequencing

Unit 4: Genome sequencing Projects **04 Hours**

Human genome project (brief history and significance); *Arabidopsis* genome project; rice genome project; applications of genomics in agriculture and human health

Unit 5: Transcriptomics **03 Hours**

Concept: EST sequencing; Gene expression studies by Microarrays and RNAseq.

Unit 6: Introduction to proteins and proteomics 06 Hours

Proteins as structural and functional unit of life; basics concept of protein structure (primary, secondary, tertiary, and quaternary), peptide bonds; brief introduction of major post-translational modifications (phosphorylation, glycosylation); introduction to enzymes; introduction to proteomics and its applications.

Unit 7: Tools for proteome analysis 05 Hours

Separation and isolation of proteins from plant tissue; purification of proteins by chromatographic techniques (column chromatography, ion exchange and affinity chromatography); separation of total cellular proteins by electrophoresis: SDS-PAGE, western blotting and ELISA.

Unit 8: Metabolomics 04 Hours

Concept of metabolomics; classes of metabolites (primary and secondary metabolites in plants); Experimental methods and instruments used in metabolomics- HPLC, GC; applications of metabolomics.

Practicals 60 hours

1. Genomic DNA extraction from cauliflower heads
2. Select 10 different organisms (5 prokaryotic and 5 eukaryotic) whose genomes have been completely sequenced and categorize them based on taxonomy, find their genome size and locate the database where their genome sequence is hosted.
3. Demonstration of gene expression studies through photographs: microarrays and RNA seq.
4. Demonstration of Sanger's DNA sequencing principle.
5. Interpretation and reading of DNA sequence chromatograms.
6. Experiment to demonstrate activity of Amylase.
7. Estimation of protein concentration through Lowry's methods/Bradford assay.
8. Demonstration of separation of proteins using SDS-PAGE (demonstration).
9. Study of proteins by Western blotting technique (digital resources/demonstration).
10. Demonstration of ELISA through kit.

Suggested readings:

1. Brown, T. A. (2020). Gene Cloning & DNA Analysis: An Introduction. 8th edn. UK: Wiley Blackwell.
2. Glick, B.R., Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6th edn. Washington, U.S.: ASM Press.
3. Griffiths, A.J.F., Doebley, J., Peichel, C, Wassarman D. (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
4. Liebler, D.C. (2002). Introduction to Proteomics: Tools for New Biology, Humana Press.
5. Primrose, S. B. Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7th edn. Victoria, Australia: Blackwell Publishing.
6. Twyman R. (2013) Principles of Proteomics, Taylor & Francis Books.
7. Watson J.D. (2017) Molecular Biology of the Gene. Pearson publishers.

8. Westermeier, R., Naven, T., Hopker, H.R. (2008). Proteomics in Practice: A guide to successful experimental design, 2nd edition, Wiley Blackwell.
9. Wood, P.L., (2021) Metabolomics. Springer Protocols.

Additional resources:

1. Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
2. Campbell, A.M. and Heyer, L.J (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson publishers.
3. Bhattacharya, S.K. (2019) Metabolomics: Methods & Protocols. Springer Protocols/Humana Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.