Department of Botany
Chaudhary Charan Singh University, Meerut

Syllabus: B. Sc. Botany (Honours) Semester-V

Core Course-XV: Plant Metabolism

Course Objectives: To study bioenergetics, biochemical pathways during photosynthesis, respiration, nitrogen metabolism, sulphur metabolism, and lipid metabolism and secondary metabolism.

Course outcomes: After the completion of the course the students will be able to:

1. Understand the role of water and weak interactions in biological systems.
2. Understand the molecular mechanism, electron transport and energy budget of photosynthesis and respiration.
3. Know about Nitrogen, sulphur, and lipid metabolism, secondary metabolites and their economic uses.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36

Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0

Unit	Topic	No. of Lectures (60 h)
I	**Weak interactions and Bioenergetics:** Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc., Bioenergetics and principles of thermodynamics, Structure and functions of ATP, pH and buffers, redox potential.	08
II	**Photochemistry and Carbon Reduction:** Historical background of photosynthesis, Light and its properties, Chloroplast, Photosynthetic pigments, Light spectrum, Action spectra and Enhancement effect, Photosynthetic apparatus, Light harvesting complexes, Electron transport system and Photophosphorylation, C3 & C4 photosynthesis, Photorespiration, CAM-Reactions and Significance.	15
III	**Carbon Oxidation:** Krebs cycle, Glycolysis, fate of pyruvate- aerobic, anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Krebs cycle, mitochondrial electron transport, oxidative phosphorylation, ATP-Synthetase, Chemiosmotic mechanism, P/O ratio, cyanide-resistant respiration, factors affecting respiration.	15
IV	**Nitrogen and Sulphur Metabolisms:** Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination, amino acid synthesis. **Lipid Metabolism**: Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination.	12
V	**Secondary Metabolisms:** Introduction to Secondary metabolites, Classification of secondary metabolites, Pathways for secondary metabolite synthesis in plants. Elementary idea of secondary metabolites like alkaloids, lignin and phenolics (terpenes, phenols).	10

Books

1. Taiz, L., Zeiger, E., Møller, I.M. & Murphy, A. (2015), Plant Physiology and Development, Sinauer Associates, Sunderland, Massachusetts, USA.
2. Heldt, H.-W. & Piechulla, B. (2011), Plant Biochemistry, Academic Press, San Diego, California, USA.
3. Hopkins, W.G. & Hüner, N.P.A. (2009), Introduction to Plant Physiology, Wiley, Hoboken, New Jersey, USA.

4. Salisbury, F.B. & Ross, C.W. (1992), Plant Physiology, Wadsworth Publishing, Belmont, California, USA.
5. Lea, P.J. & Leegood, R.C. (1999), Plant Biochemistry and Molecular Biology, Wiley, Chichester, West Sussex, UK.
6. Devlin, R.M. & Witham, F.H. (1983), Plant Physiology, Willard Grant Press, Boston, Massachusetts, USA.
7. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman, Macmillan.
8. Biochemistry (Fifth Edition). Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. Published by W.H. Freeman
9. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.
10. Voet, D. and Voet, J.G., Biochemistry (3rd ed.), 2005, John Wiley & Sons.
11. Mathews, C.K., Van Holder, K.E. & Ahren, K.G. Biochemistry (3rd ed.), 2000, Pearson Education.
12. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.
13. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
14. Lincoln Taiz and Zeiger. Plant Physiology (Fifth Edition). Sunderland, MA : Sinauer Associates.

Syllabus: B. Sc. Botany (Honours) Semester-V

Core Course-XVI: Elementary Biotechnology

Objectives

1. To introduce the basic principles and scope of biotechnology.
2. To explain gene cloning, recombinant DNA technology and gene transfer methods.
3. To provide basic knowledge of plant tissue culture and transgenic plants.
4. To introduce microbial, enzyme and environmental biotechnology.
5. To explain IPR and ethical issues related to biotechnology.

Course Outcomes: After the completion of the course the students will be able to:

1. Explain the basic concepts of biotechnology and genetic engineering.
2. Describe gene cloning, vectors and gene transfer methods.
3. Explain the production and uses of transgenic plants.
4. Describe important plant tissue culture methods.
5. Discuss the uses of biotechnology in agriculture, industry and environmental protection.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36

Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0

Unit	Topic	No. of Lectures (60 h)
I	Definition, principles and scope of Biotechnology. Basic concept of genetic engineering, Recombinant DNA technology, Enzymology of genetic engineering: Restriction enzymes, DNA ligase, Polymerase, etc.	05
II	Cloning vehicles: Plasmids, Cosmids, Lambda phage, Charon phage, yeast plasmids. Binary and shuttle vectors, Artificial chromosomes. Gene cloning: principles and techniques, choice of vectors, DNA synthesis and sequencing. Gene libraries: mRNA isolation, cDNA synthesis, cloning and amplification of gene libraries. Genomic DNA libraries, Methods of transferring desired gene into vectors, transformation techniques.	15
III	Screening for selection of clones: replica plating method, colony hybridization. Gene delivery methods: Plant viruses, Agrobacterium mediated gene transfer (biological), Particle gun bombardment (gene gun),	15

	microinjection, electrophoration. Transgenic plants (GMO): Insect resistance, Herbicide resistant plants, golden rice, Bt cotton, Bt brinjal, flavr savr tomato.	
IV	Plant Tissue Culture: General introduction, history, scope, applications, micropropagation, sterilization methods. Culture media: Composition and types of culture medium, inoculation, incubation and acclimatization. Organ culture: Anther culture and embryo culture. Somatic Hybridization: Isolation, fusion and protoplast culture, Somaclonal variation & cryopreservation.	15
V	Enzyme biotechnology, Metabolic engineering for overproduction of metabolites. Microbial biotechnology: isolation and genetic manipulation of microbes, production of chemicals, microbes for cleaner technology (pollution control). Bioremediation, bioenergy and biofuel. Intellectual Property Right (IPR) and Bioethics.	10

Essential Reading:

1. Gupta, P.K. (2018), Elements of Plant Biotechnology, Rastogi Publications, Meerut, Uttar Pradesh, India.
2. Chawla, H.S. (2011), Introduction to Plant Biotechnology, Oxford & IBH Publishing, New Delhi, India.
3. H D Kumar Modern concept of Biotechnology, Vikas Publishing House, Pvt. Ltd., New Delhi.
4. Singh, B. D. (1998). Biotechnology. Kalyani Publishers, Ludhiana
5. Joshi, P. (2002). Genetic Engineering and Its Applications. Agrobios (India), Jodhpur

Suggested Reading:

1. Gupta, P.K. (2010), Elements of Biotechnology, Rastogi Publications, Meerut, Uttar Pradesh, India.
2. Singh, B.D. (2004), Biotechnology: Expanding Horizons, Kalyani Publishers, New Delhi, India.
3. Chawla, H.S. (2011), Introduction to Plant Biotechnology, Oxford & IBH Publishing, New Delhi, India.
4. Slater, A., Scott, N.W. & Fowler, M.R. (2008), Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press, Oxford, UK.
5. Primrose, S.B. & Twyman, R.M. (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing, Oxford, UK.
6. S S Purohit and S K Mathur; Biotechnology-Fundamentals and Application- Agrobotanica, India.

A. J. Nair Introduction to Genetic Engineering & Biotechnology. Jones & Bartlett Publishers, Boston,USA.

7. Mantell, S. H. and Smith, H. (Eds.) (1983). Plant Biotechnology. Cambridge University Press, Cambridge.
8. Dodds, J. H. and Roberts, L. W. (1985). Experiments in Plant Tissue Culture. Cambridge University Press, Cambridge.
9. Swaminathan, M. S. (1991). Biotechnology in Agriculture – A dialogue. MacMillan India, New Delhi.
10. Kung, S. and Arntzen, C. J. (Eds.). (1989). Plant Biotechnology. Butterworth, Boston.
11. Grierson D (Ed.). (1991). Plant Genetic Engineering: Plant Biotechnology Series, Volume I. Blockie, Glasgow, London.
12. Charles, S. G. and Robert, T. F. (1992). Transgenic Crops. Sci. Am. pp. 62 – 69.
13. Bengochea, T. and Dodds, J. H. (1986). Plant Protoplasts: A Biotechnological Tool for Plant Improvement. Chapman & Hall, New York.
14. Trivedi, P. C. (2000). Plant Biotechnology: Recent Advances. Panima Publishing Corporation, New Delhi.
15. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Oxford & IBH Publishing CO. Ltd., New Delhi.
16. Lorz, H. and Wenzel, G. (2004). Biotechnology in Agriculture and Forestry. Springer-Verlag.
17. Henry, R. J. (2001). Plant Genotyping: The DNA Fingerprinting of Plants. CABI Publishing, Oxon, UK.
18. Singh, B. D. (1998). Biotechnology. Kalyani Publishers, Ludhiana

Syllabus: B. Sc. Botany (Honours) Semester-V
Elective Course- Ia: Cytogenetics and Plant Breeding
Objectives 1. To explain the structure and function of the chromosomes. 2. To introduce cell division and changes in chromosome number and structure. 3. To explain important cytogenetic techniques used for chromosome study. 4. To provide knowledge of basic plant-breeding methods. 5. To introduce molecular breeding, crop improvement and plant breeders' rights.

Course Outcomes: After the completion of the course the students will be able to:

1. Describe cell division and chromosome organization.
2. Identify important changes in chromosome number and structure.
3. Explain chromosome banding, FISH and GISH techniques.
4. Describe selection, hybridization, heterosis and mutation breeding.
5. Explain the use of molecular markers in crop improvement.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36

Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0

Unit	Topic	No. of Lectures (60)
I	Cell cycle: mitosis: open and closed mitosis, amitosis, meiosis. Historical development and scope of cytogenetics, chromosomal nomenclature, chromatids, centromere, telomere, satellite, secondary constriction.	03
II	Organization of chromosomes- Nucleic acid and histones- types and classification. Lampbrush chromosomes and polytene chromosomes- Karyotype and idiogram. Variation in chromosome number (Numerical aberrations): aneuploidy and Euploidy-haploidy, Role of polyploidy in evolution and crop improvement. Variation in chromosome structure (Structural aberrations): deletion, duplication, inversion, and translocation; Down syndrome, Turner syndrome, Klinefelter syndrome, Cri-du-chat, Prader–Willi, Angelman syndromes.	12
III	Chromosome pairing: Synaptonemal complex, somatic association, Rabl configurations and its role in pairing, biochemical basis of chromosome pairing. Chromosome banding techniques for identification of chromosomes: Q bands, C and N bands, G bands, R bands, chromatin remodeling. Principles of molecular hybridization: Fluorescence in situ hybridization (FISH) and Fibre-FISH, GISH.	15
IV	Plant introduction. Agencies of plant introduction in India, Procedure of introduction, Acclimatization, Achievements of plant breeding. Selection - mass selection, pure line selection and clonal selection. Genetic basis of selection methods, Hybridization: Procedure of hybridization, intergeneric, interspecific, intervarietal hybridization with examples. Composite and synthetic varieties	15
V	Male sterility, Heterosis and its exploitation in plant breeding, Mutation breeding, Inbreeding depression. Molecular Breeding (use of DNA markers in plant breeding), Achievements in India, Breeding for quality traits, breeding for biotic resistance, breeding for abiotic stress. Plant breeders' rights and regulations for plant variety protection, and farmers' rights.	15

Essential Readings:

1. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
2. Cytogenetics, Plant Breeding & Nanotechnology - Dr. M.P Singh, Dr. Suman Chauhan, Dr. Sushma Sharma.
3. Principles of Plant Genetics and Breeding. John Wiley & Sons. Russell PJ. 1998.
4. Brooker, R.J. (2012), Genetics: Analysis and Principles, McGraw-Hill, New York, USA.
5. Molecular Biology of the Cell (Garland Science, Indian edition) - Bruce Alberts

Suggested Reading:

1. Simmonds NW. 1990. Principles of Crop Improvement. English Lang. Book Society.
2. Gupta, P.K. (1995), Cytogenetics, Rastogi Publications, Meerut, Uttar Pradesh, India.
3. Singh, B.D. (2005), Plant Breeding: Principles and Methods, Kalyani Publishers, New Delhi, India.

4. Allard, R.W. (1981), Principles of Plant Breeding, John Wiley & Sons, New York, USA.
5. Snustad, D.P. & Simmons, M.J. (2000), Principles of Genetics, John Wiley & Sons, New York, USA.
6. Sharma, J.R. (1994), Principles and Practices of Plant Breeding, Tata McGraw-Hill, New Delhi, India.
7. Gupta SK. 2005. Practical Plant Breeding. Agribios.
8. Gardner, R.J.M., Sutherland, G.R., & Shaffer, L.G. Chromosome Abnormalities and Genetic Counseling (Oxford University Press)
9. Cytogenetics - Gupta, P.K. (Rastogi Publications, Meerut, India)
10. Bajpai, A.K. & Bajpai, P. Advanced Cytogenetics (APH Publishing Corporation, India) – Focuses on cytogenetic techniques and applications.
11. Bhat, T.A. Plant Cytogenetics (CRC Press, with Indian distribution) – A plant-focused reference, especially for agricultural/plant biology students
12. Practical Manual on Plant Cytogenetics Hardcover – by Ram J. Singh
13. Plant propagation by Tissue Culture Volume 1 George, Edwin F., Hall, Michael A., De Klerk, Geert-Jan (Eds.), (Springer 2008)
14. Plant tissue Culture: Theory and Practice by SS Bhojwani and MK Razdan. Elsevier.
15. Principles of Gene Manipulation by Primrose and Twyman. Wiley-Blackwell publishers.
16. Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
17. Chahal GS and Gossal, SS. 2002. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House.
18. Chopra VL. 2004. Plant Breeding. Oxford & IBH.
19. George A. 2012. Principles of Plant Genetics and Breeding. John Wiley & Sons.
20. Singh S and Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS

Syllabus: B. Sc. Botany (Honours) Semester-V

Elective Course-Ib: PLANT STRESS BIOLOGY

Objectives:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops. The following are the specific objectives of this course:

1. Identify key abiotic and biotic stress factors affecting plants and explain the associated physiological, biochemical, and molecular responses.
2. Examine plant signaling pathways and adaptive strategies such as avoidance, acclimation, and resistance under stress conditions.
3. Gain hands-on experience in plant identification, vegetation assessment, and classification techniques, with emphasis on ecological and agricultural relevance.
4. Apply principles from plant physiology, molecular biology, and biochemistry to analyze plant-environment interactions and stress resilience.
5. Critically assess transgenic and biotechnological approaches to enhance plant tolerance to climate stress and improve crop productivity

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

1. Identify different types of plant stresses and their effects on plant physiology.
2. Understand the molecular and biochemical responses of plants to stress.
3. Analyze plant adaptation and tolerance mechanisms under stress conditions.
4. Explore strategies to enhance plant resilience against environmental challenges.
5. Apply knowledge of plant stress biology in agricultural and environmental contexts.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36
Total number of Lectures : Tutorials : Practicals (hours per week): 2:0:2	

Unit	Topic	No. of Lectures (60 h)
I	**Introduction to Plant Stress Biology, Abiotic and Biotic Stresses:**	8+16

	• Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity. • Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms. • Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms- exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline. • Temperature - Cold and heat stress (in brief). • Stress caused by Pathogens, Herbivores, Parasitic plants, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity (in brief).	
II	**Stress Sensing and Signaling Mechanisms:** Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Calcium signaling and binding proteins.	8+16
III	**Stress Tolerance Mechanisms:** Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, Phenolics and Terpenoids), Chaperones (Heat Shock Proteins).	7+14
IV	**Crop Improvement Strategies:** Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).	7+14

Essential Readings:

1. Taiz, L., Zeiger, E., Møller, I.M. & Murphy, A. (2015), Plant Physiology and Development, Sinauer Associates, Sunderland, Massachusetts, USA.
2. Jenks, M.A. & Hasegawa, P.M. (2005), Plant Abiotic Stress, Blackwell Publishing, Oxford, UK.
3. Pessarakli, M. (2005), Handbook of Plant and Crop Physiology, CRC Press, Boca Raton, Florida, USA.
4. Pareek, A., Sopory, S.K., Bohnert, H.J. & Govindjee (2010), Abiotic Stress Adaptation in Plants, Springer, Dordrecht, Netherlands.
5. Hopkins, W.G. & Hüner, N.P.A. (2009), Introduction to Plant Physiology, Wiley, Hoboken, New Jersey, USA.

Suggested Readings:

1. Lambers, H., Chapin, F.S. & Pons, T.L. (2008), Plant Physiological Ecology, Springer, New York, USA.
2. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
3. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
4. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
5. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

Syllabus: B. Sc. Botany (Honours) Semester-VI	
Core Course- Practical VI	
Objectives: To Perform at least 10 exercises from each part. **Course Outcomes:** After performing experiments from each units, the students will be able to gain practical knowledge and skills in studying plant metabolism, basic biotechnology techniques, Plant breeding and cytogenetics, and Plant responses to biotic and abiotic stresses through basic laboratory techniques.	
Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36
Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0	

Unit	Topic	No. of Lectures (60 h)
I	**PRACTICALS- Plant Metabolism** 1. Preparation of solutions- percentage, molar and normal solutions, dilution from stock solution, buffers solutions etc. 2. Separation of amino acids by paper chromatography 3. Separation of plastidial pigments by solvent and paper chromatography 4. Detection of organic acids: citric, tartaric, oxalic and malic from samples 5. Qualitative Analysis of carbohydrates 6. Estimation of reducing sugar by anthrone method 7. Qualitative Analysis of Lipids, Amino acids and Proteins 9. Separation of proteins through SDS-PAGE (Sodium Dodisyl Sulphate-Polyacrylamide gel electrophoresis) 10. To study the effect of HCO_3^- concentration on oxygen evolution during photosynthesis in an aquatic plant and to find out the optimum and toxic concentration. 11. To study effect of light intensity on oxygen evolution in photosynthesis using Wilmott' bubble 12. Determination of the RQ of germinating seeds	45
II	**PRACTICALS- Elementary Biotechnology** 1. To study basic laboratory techniques used in biotechnology. 2. To study the isolation of genomic DNA from plant material. 3. To study the isolation of plasmid DNA and quantification of DNA. 4. To study the separation and visualization of DNA fragments by gel electrophoresis. 5. To study the principle and application of restriction enzymes. 6. To study the isolation of plant protoplasts. 7. To study protoplast fusion and somatic hybridization.	45
III	**PRACTICALS: Cytogenetics and Plant breeding** 1. To study the structure and morphology of chromosomes. 2. To study different stages of mitosis using onion root cell. To study different stages of meiosis using Onion flower bud 3. Chromosome counting in onion root cells. 4. To study the preparation of temporary chromosome slides and chromosome staining techniques. 5. To study the preparation and identification of polyploid plants. 6. To study the preparation of a karyotype. 7. To study emasculation and bagging techniques and artificial pollination in plants. 8. To study hybridization techniques in crop plants. 9. To study selection methods used in plant breeding. 10. To study pure-line selection. 11. To study hybridization as a method of crop improvement. 12. To study mutation and polyploidy breeding.	
IV	**PRACTICALS: - Plant Stress biology** 1. To study the effect of salt stress on seed germination percentage. 2. To study the effect of salt stress on plant shoot and root length. 3. To study the effect of stress on chlorophyll content. 4. To determine electrolyte leakage in stressed plants.	

	5. To determine SOD or peroxidase enzyme activity in control and stress plants. Experiments through demonstration (through photographs) 6. To study the plant responses under environmental stress (Stomatal closure, Leaf curling, Root alteration, Stunted plant growth, Wilting). 7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile. 8. To study the effect of stress on plant cell wall and membrane. 9. To study the effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, SAR).	

Syllabus: B. Sc. Botany (Honours) Semester-VI

Core Course-XVII: BIODIVERSITY AND PHYTOGEOGRAPHY

Objectives:

1. Study about scope and level of biodiversity and know about economic importance of biodiversity.
2. Examine different indices and major cause of biodiversity loss.
3. Apply different types of strategies for conservation of biodiversity.
4. Critically assess different types of Indian vegetation and principles of phytogeography.

Course Outcomes

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

1. Identify different levels of biodiversity and economic importance of biodiversity.
2. Understand the measurement methods and loss of biodiversity.
3. Analyze conservation strategies of biodiversity under various conditions.
4. Explore strategies to enhance plant resilience against environmental challenges.
5. Apply knowledge of phytogeography in environmental contexts.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36

Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0

Unit	Topic	No. of Lectures (60 h)
I	**Plant diversity and its scope**- Ecology diversity (Alpha, beta and gamma), Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agro-biodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	15
II	**Measurement and loss of Biodiversity:** Diversity indices: Species Richness (S), Shannon–Wiener Index (H′), Simpson's Index (D), Simpson's Diversity Index, Reciprocal Simpson Index, Margalef's Richness Index, Menhinick's Index, Pielou's Evenness Index (J′), Berger–Parker Index, Sorenson's coefficient. Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agro-biodiversity, Projected scenario for biodiversity loss, Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication	20
III	**Conservation of Biodiversity:** Conservation of genetic diversity, species diversity and ecosystem diversity, In situ and ex situ conservation, social	10

	approaches to conservation, Biodiversity awareness programmes, Sustainable development.	
IV	**Phytogeography:** Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.	15

Essential Readings:

1. Polunin, N. (1961), Introduction to Plant Geography and Some Related Sciences, Longmans, London, UK.
2. Good, R. (1974), The Geography of the Flowering Plants, Longman, London, UK.
3. Krishnamurthy, K.V. (2003), An Advanced Textbook on Biodiversity: Principles and Practice, Oxford & IBH Publishing, New Delhi, India.
4. Sharma, P.D. (2019), Ecology and Environment, Rastogi Publications, Meerut, Uttar Pradesh, India.
5. Text Book for Environmental Studies for Undergraduate Courses; 3rd Edition Erach Bharucha for UGC, 2021 Orient Black swan Pvt Ltd.

Suggested Readings:

1. Jeffries, M.J. (2006), Biodiversity and Conservation, Routledge, London, UK.
2. Schimper, A.F.W. (1903), Plant-Geography upon a Physiological Basis, Clarendon Press, Oxford, UK.
3. Primack R.B. (2006) Essentials of Conservation Biology (4th ed.), Sinauer Associates, Sunderland.
4. Groom, M. J., Meffe, G. R. and C. R. Carroll. 2006. Principles of conservation biology. Sinauer associates, Inc., USA.
5. Magurran, A. E. 1988 Ecological Diversity and its Measurement. Princeton University Press, USA
6. http://eagri.org/eagri50/ENVS302/pdf/lec06.pdf
7. https://ugcmoocs.inflibnet.ac.in/assets/uploads/1/115/3832/et/SCRIPT%2013%20ch-4b200228090902022929.PDF
8. https://www.fao.org/4/y5490e/y5490e0a.htm
9. Vogiatzakis, I. (2014). Indices for Monitoring Biodiversity. In: Michalos, A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_1433

Syllabus: BSc Botany (Honours) Semester-VI

Core Course XVIII: Introduction to Bioinformatics

Objectives

1. To introduce the basic concepts and scope of bioinformatics.
2. To provide knowledge of biological sequence and structure databases.
3. To explain methods of DNA and protein sequence analysis.
4. To introduce sequence alignment, gene prediction and phylogenetic analysis.
5. To familiarize students with plant genome databases and bioinformatics tools.

Course Outcomes: After the completion of the course the students will be able to:

1. Explain the basic concepts and applications of bioinformatics.
2. Search and retrieve information from biological databases.
3. Perform basic sequence searches using FASTA and BLAST.
4. Explain single and multiple sequence alignment.
5. Use basic tools for gene prediction and phylogenetic analysis.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36
Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0	

Unit	Topic	No. of Lectures (60)
I	An overview of bioinformatics: Origin, introduction, objective of bioinformatics, kind of data used in bioinformatics, multiplicity of data and redundancy. Scope of bioinformatics.	05

II	Sequence and structure databases: Nucleic acid data bases (EMBL, GenBank, DDBJ), protein data bases (SWISS-PROT, TrEMBL PIR-PSD, UNIProt as a single database), URLs (Uniform resource locators) of databases, SWISS-2DPAGE, KEGG, COGS, PROSITE, etc. Sequence cluster database (ProDom, Cluster, SYSTERS, ProtoMap); structure databases (CCDC, DSSP, SCOP, CATH, etc.).	15
III	Introduction to sequence analysis, models for sequence analysis (local, global, end free space alignment and gap penalty), introduction to applications of dot matrices, application of FASTA and BLAST programmes (introduction, BLAST output, significance of BLAST results, recommended steps in BLAST)	15
IV	Multiple sequence alignment (MSA), structural & evolutionary alignment, Software tools assisting in the analysis of multiple alignments, gene prediction, phylogenetics tree construction. Orthologous versus paralogous, speciation and duplication	10
V	Plant genome databases: Introductory account of NCBI's GenBank, (dbEST, UniGene), TIGR (TIGR Gene Indices); PlantGDB (TCs, TUGs, GeneSequer); GrainGenes (Gramene, Komugi, MaizeDB; TAIR, CUGI; softwares for genome research (phred/phrap/consed; crossmatch; TIGR's suite of tools; EBI's suit of tools; Staden package). Bibliographic databases	15

Essential Reading:

1. Mount, D.W. (2004), Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA.
2. Lesk, A.M. (2019), Introduction to Bioinformatics, Oxford University Press, Oxford, UK.
3. Baxevanis, A.D. & Ouellette, B.F.F. (2005), Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley, Hoboken, New Jersey, USA
4. Bioinformatics by David Mount, Cold Spring Harbor Laboratory, (1989).
5. Bioinformatics: A practical guide to the analysis of genes and proteins. Ed. By Baxevanis, 3rd . Edition, (1998) John Wiley & Sons, Inc. Publication.

Suggested Reading:

1. Xiong, J. (2006), Essential Bioinformatics, Cambridge University Press, Cambridge, UK.
2. Compeau, P. & Pevzner, P. (2015), Bioinformatics Algorithms: An Active Learning Approach, Active Learning Publishers, La Jolla, California, USA
3. Brown SM (2000). Bioinformatics: A Biologist's Guide to Biocomputing and the Internet. Eaton Publishing
4. Rastogi SC, Mendiratta N, Rastogi P (2003). Bioinformatics: Concepts, Skills and Applications. CBS Publishers, New Delhi
5. Baxevanis AD, Ouellette BFF Eds. (2001). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2nd Edition). John Wiley & Sons
6. Sharma TR (2009). Genome Analysis and Bioinformatics: A Practical Approach. IK International, New Delhi
7. Introduction to Bioinformatics by V. Kothekar, 1 st Edition, (2006), Dhruv Publications, Delhi.
8. Bioinformatics: A modern approach by Vittal R. Srinivas, Prentice/ Hall of India Pvt. Ltd. New Delhi, (2005).
9. Bioinformatics: Sequences, structure and databanks by Des Higgins and Willie Taylor, Oxford University Press, (2000).

Syllabus: B. Sc. Botany (Honours) Semester-VI

Elective Course-2a: PLANT TISSUE CULTURE

Objectives

1. To impart foundational knowledge of plant tissue culture techniques and their theoretical principles.
2. To familiarize students with the historical development and key contributors in plant tissue culture.
3. To provide hands-on understanding of media preparation, explant selection, and aseptic techniques.
4. To expose learners to advanced applications such as micropropagation, protoplast fusion, and somatic embryogenesis.

5. To develop entrepreneurial and research skills for applying tissue culture in agriculture, biotechnology, and industry.

Course Outcomes: After successful completion of the course, students will be able to:

1. Explain the historical background and basic principles of plant tissue culture, and define key terminology.
2. Identify various types of tissue culture media, their components, and their physiological relevance.
3. Demonstrate knowledge of sterile techniques, explant preparation, and culture initiation.
4. Apply tissue culture methods such as micropropagation, protoplast culture, anther culture, and embryo rescue in crop improvement.
5. Evaluate advanced applications like artificial seeds, secondary metabolite production, cryopreservation, and germplasm conservation for commercial and biodiversity goals.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36

Total number of Lectures : Tutorials : Practicals (hours per week): 4:0:0

Unit	Topic	No. of Lectures (60 h)
I	**Plant Tissue Culture:** Historical perspective (Major contributions of Haberlandt, Laibach, White, Reinert and Steward, Murashige and Skoog, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); Importance of plant tissue culture as tools for fundamental and applied plant sciences, Future prospects in improving cash crops, application of tissue culture in propagation of medicinal plants and forest trees, Cryopreservation; Germplasm Conservation.	10
II	**Requisites of Plant Tissue Culture and Plant regeneration:** Requirement of plant tissue culture laboratory- Equipment, instruments, glassware and plastic wares, Aseptic technique- contaminants and sterilization, Plant tissue culture medium: media preparation (basal medium), types and composition of media, roles of nutrients (major and minor), vitamins, hormones and others (coconut water, activated charcoal), gelling agents and their uses, Use of plant growth regulators in plant tissue culture, Cellular totipotency, Organogenesis (direct and indirect), Somatic embryogenesis and its significance, Artificial seed (encapsulation and its potential uses).	15
III	**Types of culture techniques:** Plant micropropagation: Methods and advantages of micropropagation, Steps of general micropropagation, important considerations and precautions, inoculation of explants; establishment of invitro cultures, ideal conditions for incubation of cultures, Somaclonal variation: Types, applications of tissue culture- derived variation and crop improvement,	10
IV	**Callus and haploid culture**: Callus culture- Induction, maintenance and application, Suspension culture (introductory idea), Haploid culture- Anther, pollen and ovary culture methods, application and utilization of haploids in agriculture, Protoplast culture- isolation and culture, protoplast fusion (somatic hybridization), cybrid production, application, Embryo and endosperm culture- procedure and application. Maintenance of cultures and subculture; regeneration of plantlets; acclimatization of tissue cultured plantlets in greenhouse/polyhouse.	10
v	**Production of useful metabolites by tissue culture techniques**: Secondary metabolites: Techniques of production of secondary metabolites; terpenes, phenolics and alkaloids- definitions and functions, Valuable natural	15

	compounds from plant cell and tissue culture and their uses as drugs- brief idea.	

Essential Readings:

1. Bhojwani, S.S. & Razdan, M.K. (1996), Plant Tissue Culture: Theory and Practice, Elsevier, Amsterdam, Netherlands.
2. Chawla, H.S. (2011), Introduction to Plant Biotechnology, Oxford & IBH Publishing, New Delhi, India.
3. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer
4. Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
5. Dantu, P.K. & Bhojwani, S.S. (2013), Plant Tissue Culture: An Introductory Text, Springer, New Delhi, India.

Suggested Readings:

1. Razdan, M.K. (2003), Introduction to Plant Tissue Culture, Oxford & IBH Publishing, New Delhi, India.
2. Bhojwani, S.S. (2012), Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam, Netherlands.
3. Vasil, I.K. (1994), Plant Cell and Tissue Culture, Springer, Berlin, Germany.
4. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
5. Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
6. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
7. Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
8. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
9. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
10. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
11. Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press.

Syllabus: B. Sc. Botany (Honours) Semester-VI

Elective Course-IIb: REPRODUCTIVE ECOLOGY

Objectives

1. To acquaint students about the diversity in floral architecture, floral rewards so that they can correlate the concepts with breeding mechanisms.
2. To help them appreciate the adaptive significance of various traits associated with pollination, seed dispersal and seedling recruitment.
3. To sensitize students towards challenges faced by flowering plants on account of climate change and other anthropogenic activities.
4. To build on the concepts of inbreeding and outbreeding depression, seed ecology and resource allocation.

Course Outcomes

After completing this course students will able to:

1. Become familiar with interesting concepts involved in understanding of reproductive ecology such as floral rewards, plant-pollinator interactions and pollinator guilds.
2. Have an understanding of intricacies and complexities involved in the reproductive success.
3. Will have background knowledge and an opportunity to utilize this knowledge to undertake interdisciplinary research.in conservation biology and other allied fields such as plant breeding.

Credit: 04	Course code:
Max. Marks: 100 (25+75)	Min. Passing Marks: 36
Total number of Lectures : Tutorials : Practicals (hours per week): 2:0:2	

Unit	Topic	No. of Lectures (total 60 h)
I	**Floral Ecology** Floral architecture (transitions between symmetrical and asymmetrical flowers,) role of pollination systems (any two examples), Phenology, Sexual systems, (monoecy, dioecy, hermaphroditism, gynomonoecious,	15

	andromonoecious etc.) cryptic sexuality- resource allocation and reproductive allocation, evolution from solitary flowering to inflorescence, floral attractants, and rewards (pollen, nectar, scent, colour).	
II	**Pollination Ecology** Pollination syndromes, (transitions from generalized and specialized pollination system, including mutualistic and non-mutualistic interactions with two examples each), pollinator guilds (concept with two examples); ambophily, pollen banks, pollen mediated gene flow, mating systems, Factors affecting pollen-pistil interactions (abiotic, biotic, and anthropogenic); inbreeding and outbreeding depression; resource allocation.	12
III	**Seed Ecology** Dispersal mechanisms (primary and secondary with two examples), viability, dormancy, germination; seedling recruitment; natural seed banks and species survival, seed shadow, seed mediated gene flow.	08
IV	**Reproductive Ecology- Challenges and Contemporary Issues** Impact of climate change on sexual reproduction, global pollinator crisis and pollination failure; crop yield reduction, habitat fragmentation and altitudinal shifts; impact of invasive species on native plants and pollinators, Effect of pollution on reproductive biology of plants	10

Essential Readings:

1. Lovett Doust, J. & Lovett Doust, L. (1988), Plant Reproductive Ecology: Patterns and Strategies, Oxford University Press, New York, USA.
2. Lloyd, D.G. & Barrett, S.C.H. (1996), Floral Biology: Studies on Floral Evolution in Animal-Pollinated Plants, Chapman & Hall, New York, USA
3. Real, L. (1983), Pollination Biology, Academic Press, Orlando, Florida, USA
4. Dafni, A., Kevan, P.G. & Husband, B.C. (2005), Practical Pollination Biology, Enviroquest, Cambridge, Ontario, Canada.
5. Barrett, S.C.H. (2002), Evolution and Ecology of Plant Reproductive Systems, Oxford University Press, Oxford, UK.

Suggested Readings:

1. Richards, A.J. (1997), Plant Breeding Systems, Chapman & Hall, London, UK.
2. Tandon, R., Shivanna, K.R., Koul, M. (Eds) 2020. Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer LINK
3. Shivanna, K.R., Tandon, R. 2014. Reproductive Ecology of Flowering Plants: A Manual. Springer LINK
4. Lovett-Doust, J., Lovett-Doust.L. 1988. Plant Reproductive Ecology: Patterns and Strategies: Oxford University Press, USA.
5. Rustagi, A., Chaudhry, B. (Eds) 2022. Plant Reproductive Ecology-Recent Advances. Intech Open, London, U.K
6. Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Laboratory Methods. Cambridge University Press.
7. Spencer C.H. Barrett & Christopher G. Eckert (1990) Current issues in plant reproductive ecology. Israel Journal of Botany 39:1-2, 5-12.
8. Nicolson, S.W., Wright, G.A. 2017. Plant–pollinator interactions and threats to pollination: perspectives from the flower to the landscape. Functional ecology 31:22-25
9. Hicks, L. 2020. Flowers colors are changing in response to climate change; Pigment changes can make plants less attractive to pollinators. Science News.

Syllabus: B. Sc. Botany (Honours) Semester-VI		
Core Course- Practical II		
Objectives: To Perform at least 10 exercises from each part. **Course Outcomes:** After performing experiments from each units, the students will be able to develop practical knowledge and skills in Biodiversity assessment, Phytogeographical studies, basic Bioinformatics tools, Plant tissue culture techniques, and Reproductive ecology through laboratory and field based activities.		
Credit: 04	Course code:	
Max. Marks: 100	Min. Passing Marks: 36	
Total number of Lectures : Tutorials : Practicals (hours per week): 0:0:8		
Unit	**Topic**	**No. of Lectures (120 h)**
I	**BIODIVERSITY AND PHYTOGEOGRAPHY** 1. To study the plant diversity in campus (field survey). 2. To calculate the Species Richness. 3. To calculate the Shannon–Wiener Index. 4. To calculate the Simpson's Index. 5. To determine the Simpson's Diversity Index and Reciprocal Simpson Index. Experiments through demonstration (through photographs) 6. To study the different biomes of India. 7. To demonstrate the effect of climatic condition on vegetation. 8. To study the in situ and ex situ conservation biodiversity.	45
II	**INTRODUCTION TO BIOINFORMATICS** 1. To study the basic concepts and applications of bioinformatics. 2. To study biological databases and their classification. 3. To study the NCBI database and its applications. 4. To study the retrieval of nucleotide sequences from NCBI. 5. To study the retrieval of protein sequences from protein databases. 6. To study the use of GenBank database. 7. To study the use of FASTA format for biological sequences. 8. To study sequence similarity searching using BLAST. 9. To study the basic use of sequence analysis tools in bioinformatics. 10. To study phylogenetic analysis using biological sequences. 11. To study the applications of bioinformatics in plant research.	45
III	**PLANT TISSUE CULTURE** 1. To study the equipment used in tissue culture: autoclave and laminar air flow chamber. 2. Preparation of Murashige & Skoog's (MS) medium. 3. Demonstration of sterilization and inoculation methods using leaf and nodal explants of carrot, *Datura*, *Brassica* etc. (any two). 4. Study of anther, embryo and endosperm culture (demonstration/photographs). 5. Study of micropropagation, somatic embryogenesis & artificial seeds (demonstration/photographs). 6. Isolation of protoplasts (demonstration/photographs) 7. Visit to a plant tissue culture facility/ Industry and submission of report.	
	Or	
	REPRODUCTIVE ECOLOGY	30

	1. To study diversity in floral architecture (type of soil, temperature, humidity etc. to be mentioned). 2. To carry out histochemical tests in pollen (proteins, lipids, starch). 3. To study the structure of nectary of any flower available in the campus (through section, whole mount). 4. To analyse nectar volume and composition (using refractometer/chromatography) 5. To study through temporary preparations - types of stigma (dry and wet) and style (hollow and solid). 6. To calculate pollen to ovule ratio and predict the mating system using established literature. 7. Study of species survival (ovule to seed ratio). 8. Effect of antibiotics on pollen germination.	

Any one from the out of two elective courses