UNIVERSITY OF DELHI

DEPARTMENT OF BOTANY

Bachelor of Science in Botany

OR

Bachelor of Botany (Honours with Research/Academic Project/Entrepreneurship)

OR

Bachelor of Botany (Honours with Research in Major in Botany)

OR

Bachelor of Science (Hons.) in Botany with Dissertation/ Academic Projects/ Entrepreneurship

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Courses offered in B.Sc (Honours) BOTANY Semester VIII with the course contents

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Department of Botany

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

[1] *these courses are already approved

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE-20: Plant Stress 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		
Integrative Plant Biology **DSC-20**	4	**2**	**0**	**2**	Semester VII	Nil

DSC 20: Integrative Plant Biology (Semester VIII)

Learning Objectives:

This course would involve study of plants to enhance the understanding of organism/s and/or traits from organismal to molecular levels integrating various core disciplines of plant biology including, but not restricted to, morphology, anatomy, development, taxonomy, inheritance, physiology, biochemistry, molecular and cell biology, genomics, proteomics and bioinformatics studies along with an evolutionary context. Additional areas would include interactions of plants with other organisms in an ecosystem, biotic and abiotic challenges and plant responses, transgenic studies (basic and applied) and an ecological or environmental perspective, wherever applicable.

Learning Outcomes:

The course would allow students to integrate various sub-disciplines that have been studied over the preceding seven semesters to develop a holistic understanding of plant systems transgressing various subject areas within plant biology. The course would include two main approaches/components:

(i) Integrated case studies on selected plants from algae to angiosperms including all aspects of their growth, development and applications as outlined above.
(ii) Selected trait- or process-based studies of plants to understand the biological, evolutionary and molecular determinants of the traits.

Both these approaches would involve study of research and review articles that discuss contemporary questions in plant biology by integrating multiple approaches towards understanding a plant system, in addition to textbooks.

The course design would allow students to study important paradigms in plant sciences, and train them in experimental design, data interpretation and adoption of multi-disciplinary approaches to solve scientific questions. The course would enable development of critical thinking skills among students and enhance their problem-solving abilities. This is an important component of the course since students in the 8th semester would be involved with research at the under-graduate level and would also be eligible to apply for Ph.D. programs after B.Sc. (Hons.) – with Research in Botany.

The detailed components of the course along with the suggested reading material for each topic are as follows:

Unit 1: Case studies on plants from algae to angiosperms (6 hours) :

Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives; Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops; The renaissance and enlightenment of *Marchantia* as a model system; *Cuscuta* the Merchant of Proteins; The origin of a land flora.

Unit 2: Trait-based studies (2 hour)
Important components of plant evolution – chloroplast acquisition, multicellularity and land colonization

Unit 3: Photosynthesis: (4 Hours)

Lighting the way: Compelling open questions in photosynthesis research; Perspectives on improving photosynthesis to increase crop yield; Air plant genomes shed light on photosynthesis innovation ;Alternative electron pathways of photosynthesis power green algal CO_2 capture

Unit 4: RNA biology in Plants (2 Hours)
Beyond transcription: compelling open questions in plant RNA biology; Small RNA-mediated DNA methylation during plant reproduction

Unit 5: Plant Development (6 hours)

Molecular mechanisms underlying leaf development, morphological diversification, and beyond; Genetic control of branching patterns in grass inflorescences; Anther development—The long road to making pollen- ;Evolution and patterning of the ovule in seed plants.; Soil minerals affect taxon-specific bacterial growth.

Unit 6: Plant-biotic interactions (2 hour)
Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives.

Unit 7: Genome-editing (2 hours)
Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops

Unit 8: Applied Botany: (6 hours)
Farming in Ocean, Drug Discovery, Biomass conversion into useful products, Cultivation of medicinal plants, Food testing for adulterants, millets, molecular taxonomy

Practicals: (60 hours)

Suggested Reading

1. Bowman., et al (2022). The renaissance and enlightenment of *Marchantia* as a model system. *The Plant Cell*, 34(10), pp.3512–3542. doi:https://doi.org/10.1093/plcell/koac219.
2. Paterlini, A., & Helariutta, Y. (2020). *Cuscuta* the Merchant of Proteins. Molecular Plant, 13(4), 533-535. https://doi.org/10.1016/j.molp.2020.01.007
3. Romanov, M. S., Bobrov, A. V. C., Iovlev, P. S., Roslov, M. S., Zdravchev, N. S., Sorokin, A. N., ... & Kandidov, M. V. (2024). *American Journal of Botany*, *111*(1), e16264. DOI: 10.1002/ajb2.16264
4. Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), pp.1352–1369. doi:https://doi.org/10.1038/s41477-022-01283-y.
5. Lighting the way: Compelling open questions in photosynthesis research Eckardt et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3914–3943, https://doi.org/10.1093/plcell/koae203
6. Perspectives on improving photosynthesis to increase crop yield Croce et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3944–3973, https://doi.org/10.1093/plcell/koae132

Additional References

7. Air plant genomes shed light on photosynthesis innovation Andrew C Willoughby. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3897–3898, https://doi.org/10.1093/plcell/koae213
8. Alternative electron pathways of photosynthesis power green algal CO_2 capture Gilles Peltier et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 4132–4142, https://doi.org/10.1093/plcell/koae143
9. Beyond transcription: compelling open questions in plant RNA biology Manavella et al. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1626–1653, https://doi.org/10.1093/plcell/koac346

10. Small RNA-mediated DNA methylation during plant reproduction Hiu Tung Chow, Rebecca A Mosher. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1787–1800, https://doi.org/10.1093/plcell/koad010
11. Molecular mechanisms underlying leaf development, morphological diversification, and beyond Nakayama et al. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2534–254. https://doi.org/10.1093/plcell/koac118
12. Genetic control of branching patterns in grass inflorescences Elizabeth A Kellogg. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2518–2533, https://doi.org/10.1093/plcell/koac080
13. Anther development—The long road to making pollen- D Blaine Marchant, Virginia Walbot. *The Plant Cell*, Volume 34, Issue 12, December 2022, Pages 4677–4695, https://doi.org/10.1093/plcell/koac287
14. Evolution and patterning of the ovule in seed plants. Rudall, P. J. *Biological Reviews*, *96*(3), 2021, 943-960. doi: 10.1111/brv.12684
15. Soil minerals affect taxon-specific bacterial growth. Finley, B. K., Mau, R. L., Hayer, M., Stone, B. W., Morrissey, E. M., Koch, B. J., & Hungate, B. A. (2022). *The ISME journal*, *16*(5), 1318-1326.
16. Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives. Franklin, K. A., Sommers, P. N., Aslan, C. E., López, B. R., Bronstein, J. L., Bustamante, E., .. & Marazzi, B. *International Journal of Plant Sciences*, Volume *177, Issue* 3, 2016. Pages 217-234, https://www.journals.uchicago.edu/doi/pdf/10.1086/684261
17. Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. Trends in Biotechnology, Volume 42, Issue 5; P560-574 May 2024

Qamar U. Zaman

DISCIPLINE SPECIFIC ELECTIVE COURSE-13: PLANT STRESS 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		
Plant Stress Biology **DSE-13**	4	**2**	**0**	**2**	Semester VII	Nil

Learning 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.

Learning Outcomes:

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

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

Unit 1: Introduction to Plant Stress Biology **2 hours**

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity, **Cross-**talk between abiotic and biotic stress responses.

Unit 2: Abiotic stress (Drought, Salt and Temperature) **8 hours**

- Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms, Role of Aquaporins in drought tolerance.
- 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)

Unit 3: Biotic Stress **4 hours**

Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity. Role of plant-associated microbiomes (endophytes, rhizobacteria) in biotic stress resistance.

Unit 4: Stress Sensing and Signaling Mechanisms **7 hours**

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Epigenetics, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Calcium signaling, Calcium binding proteins.

Unit 5: Stress Tolerance Mechanisms **7 hours**

Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 6: Crop Improvement Strategies **2 hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

Practicals: **60 hours**

1. To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
2. To study the effect of stress (any one) on chlorophyll content.
3. To determine electrolyte leakage in stressed plants.
4. Estimation of total phenolic content using Folin-Ciocalteu regent.
5. To determine SOD or peroxidase enzyme activity in control and stress plants.

Experiments through demonstration (through photographs)

6. Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) and Effect of ABA.
7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile.
8. Effect of stress on plant membranes.
9. Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR).

Suggested Readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -14: Immunological Concepts and Applications in Plant Science

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunological Concepts and Applications in Plant Science DSE-14	4	**2**	**0**	**2**	Semester VII	Nil

Credits:2(T) + 2(P) = 4

Learning Objectives:

1. Understanding and Protecting Against Diseases

2. To understand how the immune system defends against viruses, bacteria, and other pathogens

3. To understand how our bodies fight off diseases

4. To Understand how the develop effective treatments and vaccines are developed and vaccines,

5. To learn how to manage conditions like autoimmune disorders.

6. To learn how organ transplantation is done

- Learning outcome:

By understanding how the immune system works, we can develop public health initiatives and preventative measures to reduce the spread of infectious diseases. Immunology gives the knowledge of effective vaccines and treatments for infectious diseases. The student will understand why the immune system sometimes attacks the body's own tissues, leading to conditions like rheumatoid arthritis, lupus, and type 1 diabetes. Immunotherapy, which harnesses the immune system to fight cancer, is a rapidly growing area of research, and understanding immunology is crucial for developing and improving these treatments. The student would understand the foundation of vaccine development, allowing scientists to create safe and effective vaccines that protect against a wide range of diseases. The topic give the knowledge about how the immune system interacts with cancer cells is crucial for developing immunotherapies that can target and destroy cancerous tumors. Immunology study helps identify specific targets within the immune system that can be manipulated to treat a variety of diseases. Immunology is essential for determining tissue and organ compatibility during transplantation, helping to prevent the rejection of donated organs by the recipient's immune system. Immunology research plays a vital role in addressing global health challenges, such as fighting pandemics and developing vaccines for diseases that affect populations worldwide.

Total lectures/Hours: 30

Unit 1: Introduction to Immunological Concepts: 5 hours

Basic concepts of immunology, Innate and Acquired (Adaptive) immunity, Human Immune system, Concepts of antigen, epitope, hapten, valence, antibodies (immunoglobulins)- structure, types (IgG, IgM, IgA, IgD, and IgE) and functions, antigen-antibody reaction, antisera and vaccines. Immune system in plants, Comparison between the plant and animal immune system.

Unit 2: Plant Immunity: 4 hours

Plant pathogens and pests, Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host -resistance, Horizontal and vertical resistance, coevolution of plant defence and pathogen attack mechanisms: the Zigzag Model. Role of Microbiomes in Plant Immunity (beneficial microbes enhancing defense).

Unit 3: Components of Plant Immunity: 10 hours

(i) **Innate Immunity/ Resistance**

Non-specific or Basal Resistance: Passive (Constitutive defenses) including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins); **Active (Inducible Defences):** Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI). Popular Models of PTI in plants- Flagellin-induced Resistance,

Pathogen Race-specific resistance: Molecular Models of specific Host-pathogen Recognition, gene-for-gene or receptor-ligand model (Flor's Model), Pathogen effectors, Intracellular nucleotide-binding leucinerich repeat receptors (NLRs), Plant Resistance (R) genes, Avirulence (Avr) proteins/ Effectors, Effector-triggered susceptibility (ETS), Effector-triggered immunity (ETI), Hypersensitive response.

(ii) **Acquired Resistance**

Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR) Priming of plant immunity for faster future responses.

Unit 4: Signal Transduction Pathways activated during Plant resistance: 5 hours

Phytohormone signaling: salicylic acid, jasmonic acid, ethylene; Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in *Arabidopsis;* Mitogen-activated protein kinase (MAPK) Cascades; The Oxidative burst (ROS); Major transcription factor families in plant immunity (WRKY, NAC, MYB, bZIP)

Unit 5: Applications of immunology in Plant Science: 6 hours

Development of disease-resistant crops, engineering enhanced resistance in crops via gene editing (e.g., CRISPR-Cas9), developing novel biopesticides/ biocontrol agents based on induced systemic resistance (ISR), genetic engineering strategies for broad-spectrum resistance by Pseudo-Response Regulator (PRR) and chimeric PRR transgenes. RNAi based antiviral resistance (siRNA).

PRACTICALS 60 hours

1. To study the structure of antibody (diagrammatic and crystal structure) digitally.
2. Study of diseased plants and identification of its causal pathogen based on visually observed symptoms (Viral, bacterial, Fungal - one disease each)
3. Analysis and interpretation of digitally represented zig-zag model
4. Analysis and Interpretation of Western blots
5. Understanding the concept of immunoprecipitation by performing immunodiffusion.
7. Study and applications of immunological techniques: ELISA, Immunodiffusion, Radioimmunoassay.

Suggested Readings:

1. Dhia Bouktila and Yosra Habachi (2021) *An Introduction to Plant Immunity*: Bentham Science Publishers, Sharjah, UAE.
2. Iakovidis, M., Chung, E. H., Saile, S. C., Sauberzweig, E., & El Kasmi, F. (2023). *The emerging frontier of plant immunity's core hubs. The FEBS journal, 290(13), 3311–3335. https://doi.org/10.1111/febs.16549*
3. Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition: McGraw Hill, New Delhi.

Additional Reading:

Agrios, G.S. (2005) Plant Pathology 5th Edition: Elsewhere Academic Press, Amsterdam.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -15: Advances in Genetics, Genomics and Plant Breeding

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Genetics, Genomics and Plant Breeding DSE-15	4	**2**	**0**	**2**	Semester VII	Nil

Learning objectives:

To give the knowledge on how to improve crop yields, disease resistance, and nutritional value, ultimately contributing to food security and sustainable agriculture.

To enable more precise and efficient plant breeding, leveraging genomic information to develop superior crop varieties.

Learning outcome:

The student will learn the identification and selection of genes associated with desirable traits like higher yield, improved grain quality, and enhanced nutritional content. They will learn to to predict the breeding value of plants, accelerating the selection process and reducing the time required to develop new varieties. They will learn the gene editing techniques like CRISPR/Cas9 enable precise modifications of plant genomes to improve specific traits, further accelerating crop improvement. It alos give insights on the increased Disease Resistance and Stress Tolerance to develop varieties with enhanced immunity to pests and diseases, as well as resilience to environmental stresses like drought, salinity, and high temperatures. By developing crop varieties with higher yields, improved nutritional value, and resistance to pests and diseases, these advances contribute to increased food security and reduced reliance on chemical inputs. Climate-resilient crops developed through genomic-based breeding can help mitigate the effects of climate change on agriculture, ensuring food production. Genomics has revolutionized plant breeding by shifting from phenotype-based selection to genotype-based selection, enabling more precise and efficient trait selection. Continued advancements in genomics and plant breeding hold immense promise for developing crops with even greater resilience, nutritional value, and yield potential, further contributing to a more sustainable and secure food future. The application of artificial intelligence and machine learning in plant breeding: is also on the horizon, promising further advancements in speed, accuracy, and efficiency.

Unit 1: Chromatin Organization and Fine Structure of Gene 02 Hours

Chromatin structure and packaging of DNA: architecture of chromosome in eukaryotes, karyotypes and ideogram. Fine structure of gene. Role of 3D genome architecture (chromosome looping, TADs) in gene regulation.

Unit 2: Crop Genetics and Molecular Cytogenetics 04 Hours

Genome analysis in crops; Utilization of aneuploids in gene localization. Evolutionary significance of chromosomal aberrations in crop improvement, molecular cytogenetical tools for identification and structural analysis of genomes, introgression studies and ploidy detection. Advances in Optical Mapping and Karyotype Evolution.

Unit 3: Applied Genetics 04 Hours

Applications of molecular cytogenetics: Alien gene transfer studies, gene mapping of agronomic traits and crop improvement in wheat, rice, tomato and cotton. Application of transposons in mutagenesis, genome mapping and evolution. Genomic approaches to minor and orphan crops.

Unit 4: Current Trends in Genomics 02 Hours

Gene discovery and deciphering gene function for improvement of crops. Applications of genomics in agriculture, health and environment.

Unit 5: Epigenomics 03 Hours

Epigenomics: DNA methylation, histone modifications and chromatin remodelling; Epialleles: inheritance and role in genetic regulation. Basic tools for studying epigenomics: Overview of Bisulfite sequencing and ChIP-Seq. Applications in crop improvement and disease management.

Unit 6: Metagenomics 02 Hours

Introduction to metagenomics; Environmental metagenomics: role in pollution control and ecosystem management. Plant microbiomes and their roles in stress tolerance and nutrient uptake.

Unit 7: Genome Editing Techniques 03 Hours

Introduction to genome editing, CRISPR-Cas9; applications of genome editing in agriculture and medicine. Ethical concerns: Designer babies, GMOs, and genome editing regulations.

Unit 8: Genetic Systems and Breeding Methods 04 Hours

Gene pools (primary, secondary and tertiary), systems of mating, breeding methods for sexually, asexually/clonally propagated crops; self-incompatibility, male sterility and apomixis. Heterosis: types, genetic and molecular basis; Inbreeding.

Unit 9: Molecular Breeding 06 Hours

Molecular DNA markers and mapping populations, construction of high-density maps, QTL mapping, Association mapping. Integration of genetic maps with physical maps/chromosomes. Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), Genomic selection and Genome Wide Association Studies (GWAS). Breeding for biotic and abiotic stresses, and quality traits. Variety development and release of new varieties, Plant breeders and Farmers' rights.

Practicals: 60 hours

1. Preparation of karyotype and ideogram from mitotic metaphase spread and analysis of degree of asymmetry.
2. Study of molecular cytogenetics: identification of progenitor genomes in allopolyploids crops using GISH (wheat, rice, tomato and cotton).
3. Mapping of ribosomal DNA gene using FISH.
4. Localization of Gene introgression using Fiber-FISH/ND-FISH.
5. Pedigree construction and analysis based on inheritance of monogenic traits in humans.
6. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
7. Search for transcription factors linked to abiotic stress (e.g., drought, salinity). Note down their family (e.g., MYB, WRKY), function, and expression pattern.
8. Study of DNA methylation in plants using methylation sensitive enzymes.
9. Exploration of Single Nucleotide Polymorphisms (SNPs) in plants and their role in trait variation using Bioinformatics databases and tools.
10. Demonstration of basic method of selfing, emasculation, hybridization and crossing techniques in field/potted plants.
11. Comparison of characteristic features of released and notified varieties, hybrid and parental lines.

12. Comparison of quality parameters in improved varieties of cereals, pulses and oilseeds.
13. Genetics/Genomics/Plant breeding in News/Societal issues: presentation on a news article. Articles should have been published within last 2 years.

Suggested reading:

1. Phundhan Singh (2014). Plant Breeding: Molecular and New Approaches. Kalyani Publishers
2. Phundhan Singh (2015). Essentials of Plant Breeding. Kalyani Publishers
3. B.D. Singh (2022). Plant Breeding: Principles and Methods, 12th Edition. MedTech Science Press.
4. Arthur M. Lesk (2017), Introduction to Genomics, 3rd Edition, OUP Oxford

- Hartl, D.L. Jones, E.W (2009), Genetics: Analysis of Genes and Genomes, 7th Edition, Jones&BarlettPublishers
- Peter S Harper (2010). Practical Genetic Counselling, 7th Edition, CRC Press
- Genetics A Molecular Approach, Russell PJ, Pearson
- Introduction to Genetic Analysis, Griffith AF et al., W H Freeman & Co
- Concepts of Genetics, Klug WS&Cummings MR, Prentice-Hall, Genetics – a conceptual approach, Pierce BA, W H Freeman & Co
- Principles of Genetics, Sunstad DP & Simmons MJ, John Wiley & sons
- Genetics Analysis of Genes & Genomes, Hartl, D.L. Jones, E.W. Jones & Barlett
- Genetic Analysis, Phillip Meneely, Oxford
- The Eukaryotic Chromosome, Bostock CJ & Summer AT, Elsevier
- Structure & Function of Eukaryotic Chromosomes, Hennig W, Springer
- Genes IX, Lewin B, Pearson
- Genome 3, Brown TA, Garland Publishing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -16: Plant Genomics, Proteomics and Bioinformatics

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Genomics, Proteomics and Bioinformatics DSE-16	4	**2**	**0**	**2**	Semester VII	Nil

Learning Objectives

- To give understanding of the entire genome, including DNA sequences, gene architecture, and functional annotations, providing a holistic view of plant biology It will give the advanced knowledge in areas like crop improvement, disease resistance, and climate change adaptation.
- To provide a comprehensive understanding of plant biology at the molecular level, enabling researchers to identify key genes, proteins, and pathways involved in various plant processes.
- This knowledge can be used to develop more resilient and productive crops through advanced breeding and genetic engineering techniques.

Learning outcome:

Genomics helps identify genes related to important traits like yield, disease resistance, and nutritional content, enabling the breeding of superior crop varieties. By understanding how genes respond to environmental stress, genomics can be used to develop plants that are more resilient to drought, heat, and other climate-related challenges. Proteomics focuses on the study of proteins, their structures, and functions, providing insights into cellular processes and protein interactions. Proteomics can identify proteins involved in defense mechanisms against pathogens, helping to develop new strategies for disease management. Proteomics helps understand how proteins respond to environmental stress, providing valuable information for developing stress-tolerant crops. Bioinformatics provides the computational tools necessary to analyze the vast amount of data generated by genomics and proteomics. Bioinformatics tools are used to build and maintain databases that store and organize plant genomic and proteomic data. Bioinformatics can be used to predict gene function, protein structure, and protein-protein interactions, providing valuable insights into plant biology.

The combination of genomics, proteomics, and bioinformatics provides a powerful approach for understanding plant biology and developing new strategies for crop improvement and adaptation. By integrating data from different omics disciplines, researchers can gain a more comprehensive understanding of plant systems, including gene regulation, protein interactions, and metabolic pathways. The insights gained from genomics, proteomics, and bioinformatics can accelerate the breeding process, leading to faster development of improved crop varietie

Unit 1: Introduction to Genomics **05 Hours**

Recap of genomic concepts: genomes, genes, and non-coding regions, prokaryotic and eukaryotic genomes. Basic concepts of structural, functional, and comparative genomics. Introduction to genomics, metagenomics, functional genomics, and system biology. Model organisms in genomics (*A. thaliana, E. coli, C. elegans, S. cerevisiae*).

Unit 2: Genome sequencing **03 Hours**

Methods for whole genome sequencing (shotgun & clone by clone), next generation sequencing, Genome sequencing projects (Human genome project, *Arabidopsis* genome project, Rice genome project).

Unit 3: Transcriptomics **02 Hours**

Transcriptome sequencing, gene expression studies by EST, microarray and RNA sequencing.

Unit 4: Basic concept of Proteomics **02 Hours**

Protein Identification, quantification, characterization, structural and bioinformatics analysis.

Unit 5: Techniques in Proteomics **06 Hours**

Conventional proteomics (Native and SDS-PAGE, 2D-PAGE, Western blotting, ELISA), chromatography (Paper, Thin Layer, Size exclusion, Gel filtration, Ion exchange, Affinity); Visual proteomics (X-ray crystallography, NMR); Gel-free, Marker free MS-analysis by nano LC-MS/MS, Data-Dependent Acquisition (DDA), targeted and global proteomics analysis including PTM analysis, localization studies and functional analysis using TargetP, KEGG and GO.

Unit 6: Applications of proteomics **02 Hours**

Basic biological research (protein interaction networks and functional proteomics); disease research and diagnosis (Cancer biomarkers and virus research); drug development; agriculture and food science (crop improvement) and environmental monitoring.

Unit 7: Introduction to Bioinformatics&Biological databases **04 Hours**

Historical background; aims and scope of bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics. Introduction to biological databases; study of following databases: NCBI - Resources and tools (BLAST, BankIt, Sequin, Webin), EMBL, DDBJ databases; Nucleic acid databases (GenBank, NDB); Protein databases (PIR, Swiss-Prot, PDB); Metabolic pathway database (KEGG).

Unit 8: Basic concepts of Sequence alignment **03 Hours**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – local and global alignment, pairwise and multiple sequence alignments.

Unit 9: Molecular Phylogeny **03 Hours**

Molecular Phylogeny, construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees- maximum parsimony, maximum likelihood and distance methods.

Practicals:

1. Sequence retrieval (protein and gene) from NCBI (formats- FASTA, GenBank and GenPept formats).
2. Perform pairwise alignment using BLAST.
3. Multiple sequence alignment (MEGA/Clustal omega).
4. Gene annotation using ORF Finder & gene prediction using GENSCAN
5. Locate the genome databases of prokaryotic and eukaryotic organisms (2 each) with completely sequenced genomes and categorize them based on taxonomy and genome size.
6. Protein Structure retrieval from PDB (in PDB format) and visualization by viewing tools (RasMol/Jmol/Mol*/Swiss 3D Viewer/PyMol).
7. To Perform Native and SDS-PAGE for separation of proteins.
8. Demonstration of 2D-PAGE for separation of protein isoforms.
9. Characterization of proteins using Western blotting.
10. Purification of proteins using Gel filtration chromatography.
11. *In-silico* characterization/analysis of proteins using localization, PTMs and functional annotation tools (using TargetP, KEGG and GO).

Suggested Reading

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