Annexure-4.01.05
AC-27.12.2024

Index
Department of Botany

SEMESTER –VII
(Under UGCF-2022 based on NEP-2020)

*these courses are already approved

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

DISCIPLINE SPECIFIC ELECTIVE COURSE-19: Genomics, Proteomics and Bioinformatics

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		
Genomics, Proteomics and Bioinformatics **DSC-19**	4	**2**	**0**	**2**	Semester V	Nil

GENOMICS

Learning Objectives:

1. Introduce advanced but accessible concepts in genomics.
2. Familiarize students with tools and applications of genomics in real-world scenarios.
3. Explore interdisciplinary aspects like metagenomics, epigenomics and their role in solving global problems.

Learning Outcomes:

By the end of this course, students will be able to:

1. Understand and explain foundational yet emerging areas like metagenomics, epigenomics, and genome editing.
2. Appreciate the applications of genomics in agriculture, health, and the environment.
3. Learn basic computational tools and their role in analyzing genomic data.
4. Discuss ethical and societal challenges associated with genomics research.

Syllabus Outline

Unit 1: Basics of Advanced Genomics (4 Hours)

1. Recap of genomic concepts: Genomes, genes, and non-coding regions.
2. Introduction to current trends in genomics: Applications in agriculture, health, and the environment.
3. Significance of understanding gene functions in solving biological problems.

Unit 2: Epigenomics Made Easy (5 Hours)

1. What is epigenomics? DNA methylation and histone modifications explained simply.
2. Basic tools for studying epigenomics: Overview of Bisulfite sequencing and ChIP-Seq.
3. Case studies: Role of epigenomics in diseases (e.g., cancer, diabetes).

4. Epigenomics in plants: Applications in improving stress resistance.

Unit 3: Metagenomics for Beginners (5 Hours)

1. Understanding metagenomics: What it is and why it matters.
2. The human microbiome: Microbes and health.
3. Environmental metagenomics: Role in pollution control and ecosystem management.
4. Simplified pipeline for metagenomics analysis: Overview of 16S rRNA sequencing.

Unit 4: Genome Editing Techniques (4 Hours)

1. CRISPR-Cas9: A beginner-friendly introduction to genome editing.
2. Applications of genome editing in medicine, agriculture, and industry.
3. Ethical concerns: Designer babies, GMOs, and genome editing regulation.

Unit 5: Single-Cell Genomics (4 Hours)

1. What is single-cell genomics? Simplifying its concept and importance.
2. Applications of single-cell genomics in studying diseases and cell development.
3. Introduction to technologies like scRNA-seq (basic overview, no in-depth technical details).

Unit 6: Genomics in Agriculture and Environment (4 Hours)

1. Importance of genomics in agriculture: Gene discovery for better crops (e.g., drought-resistant rice).
2. Environmental genomics: Applications in studying biodiversity and conservation.
3. How genomics helps fight climate change: Genomic solutions for sustainable development.

Unit 7: Ethical and Societal Implications of Genomics (4 Hours)

1. Simplified discussion on genomics ethics: Privacy, data sharing, and equity.
2. Societal challenges: How genomics impacts healthcare and agriculture.
3. Genomics in everyday life: Personalized medicine and its pros/cons.

PROTEOMICS

Learning Objectives:

1. Introduce advanced concepts in proteomics.
2. Familiarize students with tools and applications of proteomics in real-world scenarios.
3. Explore functional and translational aspects of proteome analysis.

Learning Outcomes:

By the end of this course, students will be able to:

1. Understand and explain the basic tools and their applications in proteomics.
2. Appreciate the translational potential of proteomics in agriculture, health, and the environment.
3. Learn basic In silico tools, including software for analyzing Post MS proteomics data.
4. Would be able to learn the technique of antibody production and purification.

Syllabus outline:

Unit 1: Gel-free, Marker free MS-Analysis by nano LC-MS/MS, Data-dependent acquisition (DDA),

Unit 2 & 3: Targeted and global proteomics analysis including PTM analysis, localization studies (Target p, BUSCA), and functional analysis using KEGG and GO.

Unit 4 & 5: Raising antibodies in mice and rabbits, isolation, purification of antiserum, and testing antibody titters in antiserum using ELISA and western blotting techniques.

BIOINFORMATICS

Unit 1: Fundamentals of Nucleic Acid Sequencing

1. Shift from Sanger sequencing to NGS
2. Evolution of NGS
3. Strengths and weaknesses of different sequencing methods
4. Complexity of genome and how it affects handling sequencing data
5. Overview of Transcriptome sequencing
6. Overview of Genome sequencing

Unit 2: Basics of Bioinformatics

1. Introduction to bioinformatics databases
2. Search engines for Bioinformatic databases
3. Basics of Bioinformatics: sequence alignment, multiple sequence alignment, molecular phylogeny
4. Introduction to genomics, metagenomics, functional genomics, and system biology.

Unit 3: Basics of Linux-Introduction to Linux, basic commands.
Unit 4: Introduction to R and its application- Installing of R console and basic operations
Unit 5: Introduction to Python and its application-Installing of Python and basic operations
Unit 6: Introduction to Java and its applications- Installation of Java and basic operations

Suggested Practical

Practical 1

Virtual Exploration of Plant Genomes

Objective: Learn to navigate and retrieve genomic information for plants.
Materials: Computers with internet access, access to databases like Gramene, EnsemblPlants, or TAIR (The Arabidopsis Information Resource).

Steps:

1. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
2. Search for a gene of interest (e.g., drought resistance or photosynthesis-related genes).
3. Record details such as gene location, sequence, function, and related pathways.
4. Compare homologous genes between two plant species using BLAST.

Learning Outcome:

Students will understand how to access and use plant genomic data for comparative analysis.

Practical 2

In-Silico Study of Plant Transcription Factors

Objective: Identify and study transcription factors involved in stress response in plants.
Materials: Computers with internet access, free tools like PlantTFDB (Plant Transcription Factor Database).

Steps:

1. Access the PlantTFDB database and select a plant species (e.g., *Arabidopsis thaliana* or *Zea mays*).
2. Search for transcription factors linked to abiotic stress (e.g., drought, salinity).
3. Note down their family (e.g., MYB, WRKY), function, and expression pattern.
4. Discuss how these transcription factors regulate plant responses to stress.

Learning Outcome:

Students will learn the role of transcription factors in plant stress biology and how to analyze plant-specific databases.

Practical 3

Study of DNA Methylation in Plants (Simple Demonstration)

Objective: Introduce students to DNA methylation analysis using basic digestion methods.
Materials: Plant DNA, restriction enzymes (e.g., methylation-sensitive enzymes like HpaII and MspI), agarose gel electrophoresis setup.

Steps:

a) Digest extracted plant DNA (from Practical 1) using methylation-sensitive enzymes.
b) Run digested DNA on an agarose gel.
c) Observe differences in digestion patterns and discuss the role of methylation in regulating gene expression.

Learning Outcome:

Students will understand epigenetic modifications in plants and their impact on gene regulation.

Practical 4

Analysis of Plant Secondary Metabolites Using Simple Colorimetric Assays

Objective: Study the role of genomics in secondary metabolite production by quantifying phenols or flavonoids in plants.
Materials: Plant extracts, Folin-Ciocalteu reagent, aluminum chloride, spectrophotometer, basic lab glassware.

Steps:

1. Prepare crude plant extracts by homogenizing leaves or stems in methanol.
2. Perform a colorimetric assay:
    a. For phenols: Mix extract with Folin-Ciocalteu reagent and measure absorbance at 765 nm.
    b. For flavonoids: Mix extract with aluminum chloride and measure absorbance at 415 nm.
3. Compare results across plant samples.

Learning Outcome:
Students will relate genomic pathways to secondary metabolite production and explore their role in plant defense and ecology.

Practical 5

Study of SNPs in Plant Genomes

Objective: Explore single nucleotide polymorphisms (SNPs) in plants and their role in trait variation.

Materials: Access to SNP databases like Gramene or dbSNP, computers with internet access.

Steps:

1. Select a plant species from Gramene or NCBI dbSNP (e.g., *Oryza sativa* or *Zea mays*).
2. Identify SNPs in a gene related to a specific trait (e.g., yield, disease resistance).
3. Discuss the functional implications of the identified SNPs (e.g., how they affect gene function or phenotype).

Learning Outcome:
Students will understand the importance of SNPs in plant genetics and how they contribute to phenotypic diversity.

Practical 6
Preparation and testing of antigens by emulsification for primary and booster injections.

Practical 7
Purification of antiserum by centrifugation.

Practical 8
In silico analysis for PTM, Localization, and functions using the above-mentioned software.

Practical 9
Basic handling of data, transcriptome assembly, batch blast, batch primer design, setting up a local blast, basic of genome assembly, and isolation of microsatellites using MISA.

Suggested Readings (Books and Articles):

a) Brown, T.A. (2017). *Genomes 4*. Garland Science. *A student-friendly introduction to genomics with clear explanations and examples.*
b) Dale, J.W., & Park, S.F. (2010). *Molecular Genetics of Bacteria*. Wiley-Blackwell. *Covers foundational concepts in bacterial genomics and applications.*
c) Allis, C.D., Caparros, M.-L., Jenuwein, T., & Reinberg, D. (2015). *Epigenetics*. Cold Spring Harbor Laboratory Press. *(Focus on the introductory sections for basics of DNA methylation and histone modifications.)*
d) Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Wiley-Blackwell. *(Chapters on metagenomics provide a straightforward introduction with practical applications.)*
e) Handelsman, J. (2004). *Metagenomics: Application in Microbial Ecology.* ASM Press. *(Focuses on simple and engaging content about microbial diversity studies.)*

f) Doudna, J.A., & Sternberg, S.H. (2017). *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution.* Houghton Mifflin Harcourt. *(Written for a general audience, this book explains CRISPR in simple terms.)*
g) Regev, A. et al. (2017). "The Human Cell Atlas." *eLife. (Overview of single-cell genomics and its goals in mapping human cells.)*
h) Varshney, R.K., Roorkiwal, M., & Sorrells, M.E. (2017). *Genomic Selection for Crop Improvement.* Springer. *(Readable sections on GWAS and genomic applications in crop breeding.)*
i) Sandel, M.J. (2009). *The Case Against Perfection: Ethics in the Age of Genetic Engineering.* Harvard University Press. *(Simplifies the ethical dilemmas posed by genomics and genome editing.)*

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - 08: Biodiversity Informatics

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		
RESEARCH METHODOLOGY **DSE-08**	4	**2**	**0**	**2**	Semester V	Nil

Total Hours: Lectures 30, Practical 60

Course Learning Objective:

This course offers overview of Research Methodology including quantitative and qualitative research in basic as well as applied aspects of Biological Sciences. It is designed to provide hands-on experience with collection, analysis and interpretation of data and also writing a report/thesis. Moreover, this course focusses on developing the skills necessary for pursuing a career in research. The students will be motivated to learn scientific investigation to solve problems, test hypothesis, develop or invent new products for the benefit of society.

Course Learning Outcome:

After completing this course, the students should be able to:

- describe basic concepts of research and its methodologies
- identify appropriate research topics and propose hypothesis
- perform literature review using library (print) and internet (online) resources
- design experiments/surveys
- collect, analyze and interpret data with appropriate software tools, represent data in tables/figures and draw conclusion
- write scientific report/ review/ thesis and prepare seminar/ conference presentations
- understand the methods of citation and referencing styles, check plagiarism and get insight
  of intellectual property rights

Unit1: Basic Concepts of Research **Lectures: 04**

Objectives, Research Methods vs Methodology, Types of Research-Quantitative vs Qualitative, Analytical vs Descriptive, Basic vs Applied, Field Research, Search engines, Literature-review and its consolidation

Unit 2: Research Design, Data Collection and Analysis **Lectures: 12**

Conceptualization a research problem, Developing a research model, Validation of the proposed model with standard procedures and attributes, Experimental design, and implementation, Observation and Data acquisition, Methods of data collection, Data quality check, Processing and Analysis Strategies; Data presentation (Tables and Figures), Interpretation

Unit 3: Ethical Issues **Lectures: 04**

Intellectual Property Rights, Copy Right, Plagiarism, Commercialization and Royalty

Unit 4: Report Writing **Lectures: 10**

Technical Research writing (Dissertation/ Reports/Research/Review papers), Citations, Acknowledgements, Research Grants/ Fellowships, Bibliography

Practicals

1. Search engines, Literature survey, identification of gap areas
2. Presentation of collated literature
3. Experimental layout, execution, observation
4. Data analysis, using softwares, tables and figures
5. Writing a report/research paper/dissertation/summary
6. Preparation of bibliography in different formats as per journal's requirements
7. Usage of software tools for checking plagiarism

Assessment Methods:

Submission and presentation of thesis/Dissertation followed by viva-voce

Keywords: Research methodology, Data analysis, Experimental design, Sampling, Research paper, Abstracts, Dissertation, Thesis, Citation, IPR, Plagiarism, Patent, Research grants, Fellowships

Suggested Readings:

1. Coley, S.M. and Scheinberg, C.A. (1990). "Proposal writing". Stage Publications.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Wadhera, B.L. (2002). Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing.
4. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
5. Anthony, M, Graziano, A.M. and Raulin, M.L. (2009). Research Methods: A Process of Inquiry, Allyn and Bacon.
6. Kothari, C.R. (2014). Research Methodology: Methods and Techniques, 2nd edition, New Age International (P) Ltd.,
7. Walliman, N. (2011). Research Methods- The Basics. Taylor and Francis, London, New York, USA.
8. Cresswell, J.W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th edition). SAGE Publications Inc.
9. Rao, G.N. (2018). Biostatistics & Research Methodology. Pharmamed Press.

10. Gary J. Burkholder, G.J., Cox, K.A., Crawford, L.M. Hitchcock, J.H. (2019). Research Design and Methods: An Applied Guide for the Scholar-Practitioner. SAGE Publications, Inc.
11. Mukherjee, S.P. (2019). A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods. CRC Press
12. Flick, U. (2020). Introducing Research Methodology: Thinking Your Way Through Your Research Project. SAGE Publications Ltd.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 09: Biodiversity Informatics

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		
Biodiversity Informatics **DSE-09**	4	**2**	**0**	**2**	Semester V	Nil

Objectives: To introduce students to an integrated area of study where concepts learnt under different courses in previous semesters are to be utilised. The field of Biodiversity informatics integrates information on systematics, ecosystems to curate, analyse and develop an information management system to provide sound scientific bases for policy decisions.

Learning Outcomes:

- **Assess** knowledge on basic principles of Ecology, Conservation, Restoration, Biodiversity, Genetics, Molecular biology.
- Introduce applications of Remote Sensing and Geographical Information System as well as Informatics.
- Provide an opportunity to learn principles of Data Capture systems, basic elements of digitisation of Biological data, some key elements of Information Science along with creation/curation of Biological Databases (collection, storage & retrieval)
- Emphasise the importance of field collection, maintenance of herbaria & specimen collections.
- Introduce relevant National and International Biodiversity Laws.

Unit 1. History of Biodiversity Informatics **02 Hours**

Introduction to Global & National movements for conservation, institutions (including National Biodiversity Authority of India, NBPGR and others) and other non-Governmental organisations (NGO s) and networks involved in biodiversity informatics.

Unit 2. Understanding Biodiversity **03 Hours**

i. Recapitulating Basic principles of Ecology & Biodiversity - Geological Time scale and evolution of life forms, Five major extinctions, Ecosystems & Ecosystems diversity: biomes, mangroves, coral reefs, wetlands and terrestrial diversity. Biodiversity Hotspots & factors of endemism.

ii. Levels of Biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of Biodiversity (latitudinal, insular).

Unit 3. Measuring/Estimating Biodiversity 08 Hours

i. Magnitude of biodiversity (Global and Indian data). Introduction to Diversity Indices (Simpson, Shannon) and estimation of Species diversity: richness and evenness, loss of species.
ii. Introduction to Metagenomics, use of ancient DNA (aDNA) for estimation of biodiversity loss.
iii. Estimating Threats to natural Biodiversity: Habitat loss and fragmentation Disturbance and pollution; Introduction of exotic species; Human intervention and Biodiversity loss; Consequences of monotypic agricultural practice
iv. Global Environmental changes, land and water use changes ; Impacts of Climate Change on Biological systems.

Unit 4 – Informatics Resources 06 Hours

i. National & International efforts in Conservation, databases GBIF, IUCN categorized-endangered, threatened, vulnerable species.
ii. Red data book and related documentation.
iii. Categories of Biodiversity informatics databases and tools based on target life cycle step : data planning and collection, data quality and fitness, data description, data preservation and publication, data discovery and integration, computational modeling and analysis.(few databases example can be chosen to explain the steps - BRAHMS, Genbank, Catalog of Life, DataOne, GBIF, BioCollections)

Unit 5 – Methods In Biodiversity Informatics 05 Hours

i. Remote Sensing/Geographical Information Systems and its applications.
ii. Data capture – citizen science, uploading information on portals (e.g. www.indiabiodiversityportal.org).
iii. Key parameters for conservation (populations reproductive ecology)
iv. Essential management practices in in-situ and ex-situ Biodiversity Management :
    a. Management of - Biosphere reserves, National Parks, Sanctuaries, Sacred groves etc.
    b. Management of Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks etc.

Unit 6. Applications Of Biodiversity Informatics 06 Hours

i. Modeling Ecosystems & Predictions, conservation plans for species/taxa/ecosystem.

ii. Definitions and concepts of system, sub-system, variables and parameters, systems analysis, modeling and simulation ((Lotka-Voltera model).

iii. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International. (This is important for IPR perspective, gives the student and faculty options for assignments/ assessments, case studies

iv. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International.

v. Designing & implementing ecological restorations.

Practicals: **60 hours**

1. Measurement of species diversity (calculation of Diversity Indices - from data collected on plant species in different areas of the campus.
2. Use of molecular markers for estimating biodiversity (DNA Barcoding).
   (simple case studies and wherever possible experiments can be performed to teach the concept).
3. Blast analyses of selected DNA sequences from the International Gene Banks.
4. Introduction to simulations based on various environmental models.
5. Applications of RS/GIS techniques for species distribution models.
6. **Experiential Learning Module**: Visit to Biodiversity Parks, study the management and species diversity, based on that prepare a proposal for enhancement/ creation of local Biodiversity Park/Community outreach activities and other attributes.

Suggested Readings:

1. Groom MJ, Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates.
2. Tandon U, Parasaran M, Luthra S (2018) Biodiversity : Law, Policy and Governance, Routledge, India
3. Wilson, Edward O., 1993, Diversity of Life. Harvard University Press, Cambridge, MA.
4. Wheater CP, Bell JR, Cook PA (2011) Practical field Ecology: A Project guide, Wiley-Blackwell
5. IUCN RED DATA BOOK - https://portals.iucn.org/library/node/16746
6. http://biodiversity-informatics-training.org/bi-curriculum/
7. https://www.tdwg.org/standards/
8. https://methodsblog.com/2015/05/26/beta_diversity/

Additional Resources:

1. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313

2. Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.

3. Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.

4. Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.

5. Sharma, B.D. (1999). Indian Wildlife Resources Ecology and Development. Daya Publishing House, Delhi.
6. www.indiabiodiversityportal.org
7. www.johnkyrk.com/evolution.swf
8. Magurran,A.E. 2013. Measuring Biological Diversity, John Wiley.
9. Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
10. Rachel Carson (1962) A Silent Spring, Houghton Mifflin Company .

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - 10: Plant Tissue Culture

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 Tissue Culture DSE-10	4	**2**	**0**	2	Class XII pass	**Nil**

Learning Objectives

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes

The successful students will be able to:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- understand the use of tissue culture techniques in plant improvement.
- apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- become an entrepreneur by establishing their own plant tissue culture lab.

Unit 1 Introduction **3 hours**

Historical perspective, Important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin.

Terminologies: Cell culture,organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants.

Unit 2 Types and composition of Media **4 hours**

Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium.

Unit 3 Techniques of Plant Tissue Culture **4 hours**

Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation.

Unit 4 Protoplast culture **5 hours**

Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications.

Unit 5Micropropagation **5 hours**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 6 Tissue culture applications **9 hours**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

Practicals **60 hours**

l. 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 tobacco, carrot, *Datura*, *Brassica* etc. (any two).
4. Study of anther, embryo and endosperm culture.
5. Study of micropropagation, somatic embryogenesis & artificial seeds.
6. Isolation of protoplasts.
7. Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

1. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
2. Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
4. Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
5. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

1. Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
2. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
3. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
4. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
5. Trigiano, R. N. (2011). 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.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - 11: Reproductive Ecology

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		
Reproductive Ecology **DSE-11**	4	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	Nil

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.

Learning Outcomes: After completing this course students will:

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.

Theory **(30 lectures)**

Unit 1

Introduction to Reproductive Ecology **(2 lectures)**

Concept of reproductive ecology: Significance and scope.

Unit 2

Floral Biology **(4 lectures)**

Floral architecture, floral phenology, sexuality, cryptic sexuality, reproductive allocation, evolution from solitary flowering to inflorescence, floral attractants, and rewards (pollen, nectar, scent, colour).

Unit 3

Pollination Ecology **(6 lectures)**

Pollination types, adaptations; plant-pollinator interactions (generalized and specialized pollination system, including mutualistic and non-mutualistic interactions), pollinator guilds; pollen banks.

Unit 4

Pollen-Pistil Interactions and Mating Strategies **(8 lectures)**

Factors affecting pollen-pistil interactions (abiotic, biotic, and anthropogenic); pollen flow. Sexual incompatibility (recognition and rejection reactions); inbreeding and outbreeding depression; resource allocation.

Unit 5

Seed Ecology **(4 lectures)**

Seed development (sexual and apomictic), dispersal mechanisms (primary and secondary), dormancy, viability, germination; seedling recruitment; seed banks.

Unit 6

Challenges and Contemporary Issues in Reproductive Ecology **(6 lectures)**

Impact of climate change on sexual reproduction**,** global pollinator crisis and pollination failure; habitat fragmentation and altitudinal shifts; impact of invasive species on native plants and pollinators.

Practical **(15 classes)**

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 study pollen-pistil interaction by demonstrating activity of (**ANY ONE)** esterase, acid phosphatase and peroxidases.

**Project work/Field Trip: Seed dispersal mechanism, Phenological calendar of flower, Estimation of Pollen Production in Anthers (with large number/ small number of pollen grains), or any other topic from the syllabus

REFERENCES

Tandon, R., Shivanna, K.R., Koul, M. (Eds) 2020. Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer LINK

Shivanna, K.R., Tandon, R. 2014. Reproductive Ecology of Flowering Plants: A Manual. Springer LINK

Lovett-Doust, J., Lovett-Doust.L. 1988. Plant Reproductive Ecology: Patterns and Strategies: Oxford University Press, USA.

Rustagi, A., Chaudhry, B. (Eds) 2022. Plant Reproductive Ecology-Recent Advances. Intech Open, London, U.K

Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Laboratory Methods.Cambridge University Press.

SUGGESTED READINGS

Spencer C.H. Barrett & Christopher G. Eckert (1990) Current issues in plant reproductive ecology. Israel Journal of Botany 39:1-2, 5-12.

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

Hicks, L. 2020. Flowers colors are changing in response to climate change; Pigment changes can make plants less attractive to pollinators. Science News

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-12)

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		
Environmental Biotechnology & Management **DSE-12**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

Learning Outcomes:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

Unit 1: Environment **5 hours**

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment 7 hours

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Xenobiotic compounds7 hours

Organic (Bio degradation of petroleum products and pesticides) and inorganic (metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of metals

Unit 4: Treatment of toxic compounds: Role of immobilized cells/enzymes, microbial remediation 5 hours

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting

Unit 5: International Legislations, Policies for Environmental Protection 3 hours

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol-1997. Environmental ethics

Unit 6: National Legislations, Policies for Pollution Management 3 hours

Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Practicals: 60 hours

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites)
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples.
4. To determine the alkalinity of water samples.
5. To determine the pH and rapid field test of soil samples (Chloride, Nitrate, and Sulphate).
6. To study microbessuspended in air and water samples.
7. A visit to any educational institute/ industry to understand the uses of microbes in environmental management and a report to be submitted for the same.

Suggested Readings:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delhi. New Age International Pvt. Limited
2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
6. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
7. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

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

DISSERTATION on Major/Minor/ACADEMIC PROJECT

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		
DISSERTATION	**6**	**-**	**-**	**-**	Class XII pass	**Nil**

Detailed Guidelines for Dissertation on Major/Minor/Academic Project

1. Dissertation on Major/Minor/Academic Project/Entrepreneurship should be based on the broad subject areas of B.Sc. (Hons.) Botany/B.Sc. Life Sciences – Botany component syllabi of Semesters I – VIII.

2. Dissertation should include a component of original research. Both Dissertation and Academic Project would include other components such as review of literature, data collection, analysis and interpretation, collation and presentation which are described in detail in point #7 below.

3. All faculty members of the Department of Botany of a college that offers B.Sc. (Hons.) Botany and/or Life Sciences will be associated with this course in addition to their regular classes.

4. Students will be required to allocate 12 hours per week (6 credits; ~180 hours per semester) in their teaching schedule to meet the credit requirements for this course.

5. Allocation of students:

   - Towards the end of Semester VI, each student will be provided with a list of faculty members along with their areas of specialization/research/teaching interest.

   - Students desiring to do a dissertation in Botany will have to register their preference for EACH faculty member from "1" to "n" wherein "n" is the total number of faculty members in the Department of Botany of a college. "1" represents the first choice and "n" represents the last choice of a student.

   - In the above example, two faculty members (I and II) offer three areas of specialization (A, B and C for Faculty I and A', B' and C for Faculty II) each. Student 1 and student II have faculty members I and II as their first and second preference, respectively. Within the offered areas with Faculty I and II, student 1 has a preference in the order A>C>B with Faculty I and C>B'>A' with Faculty II. For student 2, the preferences are B>C>A for Faculty I and C>A'>B' for Faculty II.

	Faculty I			Faculty II		
Research Area	A	B	C	A’	B’	C
Student 1	1-a	1-c	1-b	2-c	2-b	2-a
Student 2	2-c	2-a	2-b	1-b	1-c	1-a

- After the declaration of results of Semester VI, a merit list will be made based on the consolidated CGPA of students. The merit list will be separate for students enrolled in B.Sc. (Hons.) Botany and B.Sc. – Life Sciences programs.

- Students who wish to do Dissertation in Botany as a Minor are required to have studied at least six papers of Botany till Semester VI with a minimum SGPA of 6.0 in at least four Botany papers. Their merit list will be prepared independently.

- Allocation of faculty member to each student will be based on the students’ merit and choice.
- Each faculty member will mentor multiple students, if required.
- Number of students per faculty will be decided using the formula: Total no. of students / Total no. of faculty.
- In case of a tie in consolidated CGPA for six semesters between two or more students opting for a faculty member, faculty member with a higher order of preference will be allocated to a student. In case of a tie at this stage, tie-breaker formulae will be applied in preferential sequence as follows:
    a. Student with greater CGPA in the designated paper of research/study
    b. Student with greater CGPA till Semester V
    c. Student with greater CGPA till Semester IV
    d. Student with greater CGPA till Semester III
    e. Student with greater CGPA till Semester II
    f. Student with greater CGPA till Semester I
- It is the prerogative of the faculty member to decide the distribution of students (under his/her mentorship) to Dissertation or Academic Project based on their aptitude and performance.

6. Evaluation

- Internal Evaluation:
    - There would a mid-term presentation by the students which would constitute the Internal Assessment for this paper.
    - Presentation would be for 10 minutes followed by a viva for 5 minutes.
    - Weightage for internal assessment in the final result would be as per guidelines of the Examination branch.
    - Assessment would be done by a three-member assessment committee constituted by the TIC of the Department of Botany of the college.

- Final Examination:

    - Final evaluation would be based on evaluation of the Dissertation / Academic Project Report, Presentation and Viva as per the detailed guidelines outlined in Point #7 below for both semesters VII and VIII.
    - Assessment would be done by a four- or five-member assessment committee comprising the TIC and two faculty members of the Department of Botany of the college and one or two external examiner(s) from the Department of Botany, University of Delhi under approval by the Head, Department of Botany. The external examiner(s) would be associated with evaluation of all reports and presentations of one college.

7. Detailed guidelines:

- **Semester VII**

During Semester VII, students will be involved with **Formulation of a research proposal / Review of literature** that would include the following activities:

- Identification of a research problem or research area of interest
- Outline the objective/s of research after discussion with the faculty mentor and a preliminary study of literature in the chosen research topic.
- Choose a clear and concise title that accurately reflects the content and focus of the research topic.
- Prepare a comprehensive report on the chosen research topic including the following:

PART A:

- Overview of the research topic and its significance
- A comprehensive review of existing literature relevant to the research topic
- Summary of key theories / findings in literature
- Gaps in the existing knowledge / literature
- Importance of proposed study in contributing to existing knowledge

PART B:

- Research material / methods / techniques to be used in the proposed study
- Requirement of specialized equipment or other resources (consumables) for the study and its availability to the student
- Detailed timeline with milestones of project/proposal
- An estimated budget for research, including costs for consumables, equipment, travel, etc.

- Presentation during end semester exam