UNIVERSITY OF DELHI

REVISED SYLLABUS

FOR

Ph.D. Program in Botany

(Semester System)

Syllabus applicable for students seeking admission to

Ph.D. Program in Botany

w.e.f. 2020-21 academic session

DEPARTMENT OF BOTANY

FACULTY OF SCIENCE

UNIVERSITY OF DELHI

DELHI – 1100 07

DOCTOR OF PHILOSOPHY
(BOTANY)
FULL-TIME PROGRAMME

RULES, REGULATIONS AND COURSE CONTENTS

DOCTOR OF PHILOSOPHY
(BOTANY)
FULL-TIME PROGRAMME

AFFILIATION

The proposed programmes shall be governed by the Department of Botany, Faculty of Science, University of Delhi, Delhi – 110007.

PROGRAMME STRUCTURE

I. SEMESTER I

The Ph.D. coursework Programme consists of one Part as under.

The coursework would consist of 10 credit courses. There would be **Two** Core Papers to be studied compulsorily by all students of the Ph.D. Botany programme,and Six Elective papers from which each student would have to select **Two** papers of their choice. There would be a confirmation viva-voce after the successful completion of the course work. The viva-voce will not have any credits as it is a mandatory requirement.

1. CORE PAPERS*(*Mandatory for all students)*		**Page No.**
RM 01	**Research Methodology**	8
RM 02	**Research and Publication Ethics**	9
II. ELECTIVE PAPERS (***Two papers from EL 01 – 06 are to be selected)*		
EL 01	**Ecology and Environment**	11
EL 02	**Plant Diversity, Systematics and Evolution**	12
EL 03	**Abiotic Stress Physiology and Biochemistry**	13
EL 04	**Genetics, Genomics and Cell Biology**	14
EL 05	**Developmental Biology and Plant Biotechnology**	15
EL 06	**Plant Stress and Gene Regulation**	16

The schedule of papers prescribed shall be as follows:

** : Core papers are mandatory for all.*

***;Elective papers will be offered as per the availability of faculty and sufficient minimum strength of students. The Ordinance VI of the University of Delhi allows students the flexibility to choose credit courses offered by other sister departments. Similarly, students of other sister departments can also opt for the electives available from the Department.*

Each paper is of 4 (30 hrs of Theory and 30 hrs of Tutorials/ Practicals/Seminars/Instrumentation) or 2 credits (15 hrs of Theory and 15 hrs of Tutorials/ Practicals/Seminars/Instrumentation).

CONFIRMATION VIVA-VOCE (SEMESTER II)***

II. SEMESTER II

Confirmation viva and outline of proposed work

***** Confirmation viva being a mandatory requirement for registration of the candidate, no credits have been assigned.**

Ph.D. Coursework is governed by the Ordinance VI of the University.

SCHEME OF EXAMINATIONS

1. English shall be the medium of instruction and examination.
2. Examinations shall be conducted at the end of course work as per the Academic Calendar notified by the University of Delhi.
3. RM 01 will be of 4 Credits (100 marks), all other papers will be of 2 Credits (50 marks) Research Methodology (RM 01), and, Research and Publication Ethics (RM 02) are mandatory for all students. Candidates can choose any two papers from the available electives (Papers EL 01 to EL 06).
4. Assessment would include continuous evaluation and an end-semester examination. These criteria could be modified based on guidelines approved by the University.

PASS PERCENTAGE

Minimum marks for passing the examination in each paper shall be 55%.
A candidate who has not secured the minimum marks to pass in each paper may reappear in the relevant paper/s in the next semester. No student would be allowed to avail of more than 2 chances to pass a paper inclusive of the first attempt.

PROMOTION CRITERIA

Students shall be required to fulfill the Credit score requirement. All students fulfilling the credit requirements will be allowed to continue with the Ph.D. course.

DIVISION CRITERIA

Successful candidates will be classified on the basis of combined results of examinations as follows:

Candidates securing 60.00% and above	:	Ist Division
Candidates securing between 55.00% and 59.99%	:	IInd Division
All others	:	Fail

ADDITIONAL QUALIFYING PAPERS TOWARDS LEARNING / ACQUIRING SKILLS

The Research Advisory Committee may advice the candidate to attend classes of Post-Graduate course being offered within or at other Departments. While passing these papers is required, no credits will be earned towards qualifying marks of the coursework.

SPAN PERIOD

Students are required to clear the coursework (excluding the qualifying papers) within one year (first two semesters)from the date of admission.

Duration of the Ph.D. program is governed by Ordinance VI of the University of Delhi.

ATTENDANCE REQUIREMENT

No student shall be considered to have pursued a regular course of study unless she/he is certified by the Head of the Department of Botany,University of Delhi, to have attended 75% of the total number of lectures and seminars conducted in each semester, during her/his course of study. Provided that she/he fulfills other conditions,the Head, Department of Botany may permit a student to continue who falls short of the required attendance percentage by not more than 10% of the lectures and seminars conducted during the Semester to continue in the program.

COURSE CONTENT FOR EACH PAPER

Submitted as Annexure A

LIST OF READINGS

Will be assigned as appropriate

ANNEXURE A

Ph.D. Course work contents

Except for RM 01, each other paper will be a stand-alone unit of 2 credits and RM 01 will be of 4 credits. RM 01 with 4 credits will have 30 hours of theory and 30 hours of Tutorials/ Practicals/Seminars/Instrumentation. All other papers with 2 credits will have 15 hoursof theory and 15 hours of tutorials/ instrumentation; practicals, projects and assignments that can be internally evaluated. Ph.D. students will take 10 course credits. Research Methodology (RM 01 and RM 02) are compulsory for all. Electives (Elective A and Elective B) will be based on students' options selected from those available from the 6 papers (EL 01- EL 06).

Semester I	**credits**
RM 01	4
RM 02	2
Elective A	2
Elective B	2
Total	10
Semester II	
Ph.D. Confirmation Seminar (including literature review and thesis proposal)	0

RM 01: RESEARCH METHODOLOGY

(04 Credits)

This course will introduce the students to the theory and practice of scientific methods, including safe laboratory practices,biostatistical concepts to design experiment, analyse, interpret and present data, appropriate practices in writing scientific documents and presentation skills, and familiarize them with writing and presentation tools and skills.

Unit 1: Introduction to Scientific Practice

IPR, Biological collections -The Convention on Biological Diversity (1992), Biodiversity Act (2002), National Biodiversity Authority, Guidelines for biological collections, Databases and their responsible use: NCBI, Biodiversity databases. Safety in the Laboratory: Chemical safety, wastes and disposal, Biological waste, transgenics. Radioactive materials, safe use and disposal.

Unit 2: Statistics for Biologists

Introduction: Distributions, summary statistics, sample and population, measures of central tendency, measures of dispersion and variability.

Hypothesis testing: One sample, two-sample, paired sample and multiple sample hypothesis. Regression and correlation: Simple linear and multiple regression, significance of *p*, coefficient of determination and correlation coefficient.

Use of t-test, chi-square test and F-statistics, Analysis of Variance (ANOVA), Experimental design: Understanding research question, sampling techniques.

Unit 3: Communication in Science

Basic instructions on the "do's" and "don'ts" of general as well as scientific writing, including use of correct grammar, punctuation, sentence structure, use of present/past tense etc.

Précis writing and editing a scientific document for linguistic, grammatical, and punctuation errors.

Effective oral scientific communication and presentation skills

Unit 4: Online Tools

Correct usage of technical language and scientific peer network.

Practical exercises

Discussion, demonstration, exercises to evaluate the familiarity with basic procedures/protocols

Guidelines for biological collections; Sampling strategies and techniques in biological sciences. Statistical tools and analysis.

Exercises such as (i) Description of a general figure and (ii) Description and analysis of scientific data (iii) Writing the précis of a scientific document (iv) Correction of a scientific document for linguistic, grammatical, and punctuation errors (v) Development of PowerPoint™ slides and oral presentation on topics assigned to students.

RM 02: RESEARCH AND PUBLICATION ETHICS

(02 CREDITS)

Theory

Unit 1: Philosophy and ethics

- Introduction to philosophy: nature and scope, concept, branches
- Ethics: definition, moral philosophy, nature of moral judgement and reactions

Unit 2: Scientific conduct

- Ethics with respect to science and research
- Intellectual honesty and research integrity
- Scientific misconduct: falsification, fabrication and plagiarism (FFP)
- Redundant publications: duplicate and overlapping publication, salami slicing
- Selctive reporting and misrepresentation of data

Unit 3: Publication ethics

- Publication ethics: definition, introduction and importance
- Best practices / standard setting initiatives and guidelines COPE (Committee on Publication Ethics), WAME (World Association of Medical Editors) etc
- Conflicts of interest
- Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice-versa, types
- Violation of publication ethics, authorship and contributorship

- Identification of publication misconduct, complaints and appeals
- Predatory publishers and journals

Practicals

Unit 4: Open access publication

- Open access publication and initiatives
- SHERPA / RoMEO online resource to check publisher copyright and self-archiving policies
- Software tool to identify predatory publications developed by SPPU
- Journal finder/ journal suggestion tools viz. JANE (Journal/Author Name Estimator), Elsevier journal finder, Springer Journal Suggester etc

Unit 5:

A. Group discussion

i. Subject-specific ethical issues, FFP (falsification, fabrication, and plagiarism), authorship
ii. Conflict of interests
iii. Complaints and appeals: examples and fraud from India and abroad

B. Software tools

i. Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit 6: Databases and research metrics

A. Databases

a. Indexing databases
b. Citation databases: Web of Science, Scopus etc

B. Research metrics

i. Impact factor of journals as per journal citation reports, SNIP, SJR, IPP, CiteScore
ii. Metrics: h-index, g index, i10 index, altimetrics

EL 01: ECOLOGY AND ENVIRONMENT
(2 Credits)

The module on population ecology will appraise the characteristic features of populations and their dynamics in relation to environmental factors influencing them. The module on Community and Ecosystem Ecologywill give students an understanding of methodology for assessing species interactions at the community level and their role in shaping of ecological niches, use of diversity indices, and understanding of ecosystem structure and functions.

Unit 1: Population Ecology

Theory

Basics of population ecology: concepts, age structure in plant populations, population dynamics, density-dependent and independent population regulations, life history strategies, metapopulation concept.

Population metrics: age-specific mortality and fecundity matrix models. Introduction to population genetic theories.Application of molecular tools in the differentiation of population and identification of parent-offspring relationships.

Unit 2: Community and Ecosystem Ecology

Theory

Fundamentals of niche concept, Ecological niche differentiation and modelling, Ecological succession and environmental factors. Diversity indices and community assessment.

Methodological developments in assessment of structure and function of ecosystems: framework for assessment and mapping of ecosystem health and services, plant defense mechanism.

Practicals

Exercises based on theory.

EL 02: PLANT DIVERSITY, SYSTEMATICS AND EVOLUTION (2 CREDITS)

This course will give students a comprehensive view of algae, bryophytes and their diversity in structure, function and ecology. The unit on Phylogenetics will give an overview of comparative biology in a phylogenetic context. This module will equip students with basic theoretical and practical skills (phylogenetic analysis software) to tackle analysis of cross-species data. The module on Plant systematic will introduce basic principles of plant nomenclature, classification, typification, identification and modern methods in plant systematics

Unit 1: Algae

Theory

Study of Diversity and distributions of algae in different habitats. Role of algae in the changing environment.

Practicals

Algal collection and culture Techniques (Microalgae and Seaweeds)

Unit 2: Bryophyte Diversity and Evolution:

Theory

Origin of bryophytes. Evolution of traits: Characteristic traits of bryophytes. Structure, breeding systems and ecological adaptations.Classification of bryophytes.Sampling methods in the collection and ecological studies of bryophytes.Mosses as model organisms.Monitoring pollution using bryophytes.

Experimental propagation and in vitro culture of bryophytes

Practicals

Exercises based on theory

Unit 3: Phylogenetic Biology

Theory

Basics of evolutionary biology: Evolution of populations, Speciation. Estimating Phylogenetic Trees: Trees and tree-thinking, Morphological data and Maximum Parsimony, Molecular data and Maximum Likelihood, Bayesian methods. Using Phylogenetic Trees in Taxonomy, Biogeography, Divergence times, Character evolution, Ecology, Comparative phylogenetic methods.

Practicals

Application of theoretical concepts using software for phylogenetic and comparative analysis

EL 03: ABIOTIC STRESS PHYSIOLOGY AND BIOCHEMISTRY
(2 Credits)

The first unit will deal with the role of lipids as signaling molecules during abiotic stress. Further, techniques applied for identification, and characterization of various plant lipids will be discussed. The unit on Photosynthesis and phytohormones under abiotic stresses will examine the effects of abiotic stresses on photosynthetic processes in plants. The third unit deals with Redox Physiology. Redox changes and redox modifications are the major physiological regulatory mechanisms during normal growth and development as well as during stress. These mechanisms and their physiological significance would be detailed under this module. Besides, differential proteomics and nanobionics would be introduced.

Unit 1: Lipids under abiotic stress

Theory

Overview: Lipids act as energy reserve, form membranes and also act as signalling molecule under various stresses. Lipids like PA, DAG, S1P, PIPs play pivotal role during plant stress. Analysis of various plant lipids: Isolation of total lipids, separation into various classes through chromatography, quantification and characterization.

Practicals

Practicals/ demonstrations based on theory

Unit 2: Photosynthesis and phytohormones under abiotic stresses

Theory

Structural, physiological and biochemical characteristics of light and dark reactions of photosynthesis, stomatal and non-stomatal limitations of photosynthesis, plant growth regulators and their roles in tolerance to abiotic stresses.

Practicals

Practicals/demonstrations based on the theory

Unit 3: Redox Physiology

Theory

Redox changes and redox modifications are the major physiological regulatory mechanisms during normal growth and development as well as during stress. These mechanisms and their physiological significance would be detailed under this module. Besides, differential proteomics and nanobionics would be introduced.

Theory

Abiotic stress signal transduction pathways. Reactive oxygen species- (ROS)/ RNS production, anti-oxidative mechanisms, physiological implications. RNS including Nitric oxide as signaling molecule in stress. PTMs of Nitric oxide.ROS-RNS (NO) crosstalk. Differential proteomics with examples from published work. Application of nanobionics to modify plant systems as sensors and better producers.

Practicals

Relevant Instrumentations, Practicals, Seminars, Tutorials based on theory.

EL 04: GENETICS, GENOMICS AND CELL BIOLOGY (2 CREDITS)

The unit on genetics and genomics will introduce students to broad patterns of genome evolution, analysis of genomes through synteny analyses and introduction to comparative genomics. Genetic Markers and Mapping unit will deal with recent advances in molecular markers and their uses in mapping and analysis of association with traits. The unit in Cell Biology will apprise students of the recent and contemporary advances in Cell Biology including structural and functional aspects of cellular and sub-cellular components.

Unit 1: Genetics and Genomics

Theory

Genome evolution: Trends and patterns, Evolutionary implications of genome size, polyploidy and genome rearrangements. Genes and their differentiation through neofunctionalization.

Tools and techniques for whole genome comparison, Comparative genomics and its applications, Structural and functional annotation of genes, deciphering plant evolutionary history.

Recent developments in molecular markers with the advent of Genomics. Considerations for developing high throughput markers. Methods for genotyping.

Maps and their relation to genome: Establishing relationships between physical maps, genetic maps and genome sequences.

Analyzing marker trait association: Methods to analyze marker trait association with emphasis on association mapping and genomic selection.

Practicals

Exercises based on theory

Unit 2: Cell Biology

Theory

Recent concepts and advances in Cell biology; Contemporary advances into structural and functional details of cell wall, membranes and organelles- their function and significance; nucleus- its components and nuclear neighbourhood; Current developments in Cell biology

Practicals

Exercises based on theory

EL 05: DEVELOPMENTAL BIOLOGY AND PLANT BIOTECHNOLOGY (2 CREDITS)

The unit on Developmental Biology will familiarize scholars with diverse approaches that help understand mechanisms of development. Introduction to developmental staging and phenotyping will assist research scholars in standardizing and designing systematic investigations of plant systems. The unit in Plant Biotechnology will deal with the basic concepts of in vitro regeneration and *Agrobacterium*-mediated transformation of plants. The role of transgenic technology in understanding basic plant biology as well as application in product development will be discussed. Students will be familiarized with experimental design, data analysis and interpretation with emphasis on experiential learning.

Unit 1: Developmental Biology

Theory

Developmental staging of plant organs. Pollen-Pistil Interactions. Agamospermy: Apomeiosis, Parthenogenesis, Autonomous and pseudogamous endosperm development. Zygotic embryogenesis -Maternal to Zygotic Transition. Cell Polarity and Patterning. Phenomics: Plant phenotyping technologies, Plant growth analysis and Phenomics tools. Molecular genetics of plant development: Resources and approaches to study plant development; case studies on plant development

Practicals

Microtomy, Microscopy, Tutorials and assignments based on theory

Unit 2: Plant Biotechnology

Theory

Basics of plant tissue culture; Introduction to genetic transformation and *Agrobacterium* biology. Design and development of transformation vectors (Restriction enzyme-mediated cloning/Recursive PCR/Gateway cloning); Genome editing; Development of transgenic plants and approaches used for genetic, phenotypic and molecular analysis; Reverse genetics approaches to study plant development, generation of mutants; Biosafety issues

Practicals

Practical exercises may be designed and given to the students for experiential learning in these topics.

EL 06: PLANT STRESS RESPONSES AND GENE REGULATION (2 CREDITS)

The unit on Interactions of Plants with Pathogens, Pests and Symbionts will introduce basic concepts in interactions of plants with their pathogens, pests and symbionts, as well methods of study. The second unit on Regulation of Eukaryotic Gene Expression will familiarize students with molecular mechanisms of gene expression regulation and tools for analysis of gene expression.

Unit 1: Interactions of Plants with Pathogens, Pests and Symbionts

Theory

Plant-pathogen/pest interactions Theories of Plant defense. Plant-pathogen/pest/symbiont interactions: Biochemical and molecular mechanisms (molecular patterns, innate immunity, induced defense responses). Management and control of pathogens and pests: Natural and engineered methods (case studies). Introduction to methods in the study of selected plant pathogens and pests.

Practicals

Exercises based on theory.

Unit 2: Regulation of Eukaryotic Gene Expression: This module will familiarize students with molecular mechanisms of gene expression regulation and tools for analysis of gene expression.

Theory

Overview of tools to study gene expression; Transcriptome analysis using next generation sequencing platforms; Regulation of gene expression by non-coding RNAs with selected case studies from plant biology; Regulation of cell cycle at molecular level with special emphasis on: 1) Cyclin-dependent kinase complexes, 2) Cytoskeleton; Hormonal regulation of gene expression

Practicals

Exercises based on theory