DRAFT

UNIVERSITY OF DELHI

MASTER OF SCIENCE - BOTANY

(Acronym for the Course)

(Effective from Academic Year 2018-19)

PROGRAMME BROCHURE

M.Sc. Botany Revised Syllabus as approved by Academic Council on XXXX, 2018 and

Executive Council on YYYY, 2018

CONTENTS

		Page
I.	About the Department	3
II.	Introduction to CBCS	4
	Scope	
	Definitions	
	Programme Objectives (POs)	
	Programme Specific Outcomes (PSOs)	
III.	Master of Science in Botany Programme Details	5
	Programme Structure	
	Eligibility for Admissions	
	Assessment of Students' Performance and Scheme of Examination Pass Percentage & Promotion Criteria:	
	Semester to Semester Progression	
	Conversion of Marks into Grades	
	Grade Points	
	CGPA Calculation	
	Division of Degree into Classes	
	Attendance Requirement	
	Span Period	
	Guidelines for the Award of Internal Assessment Marks	
	Master of Science in Botany Programme (Semester Wise)	
IV.	Course Wise Content Details for Master of Science in Botany Programme	13

I. About the Department

- *Historical background of Department*

  The Department of Botany, University of Delhi, was established in 1947 with about 50 students and few faculty members. The dynamic and visionary contributions of several renowned botanists earned the Department international recognition for its teaching and research. Based on exemplary performance, the Department was recognized as a UGC Centre for Advanced Studies (CAS) in Botany. In the recent past, the Department received grants under the UGC-COSIST scheme and continues to receive assistance under DST-FIST, UGC-SAP and DST-PURSE programmes.

- *Department highlights in terms of its ranking, courses*

  The Department of Botany is committed to expand and absorb the wide diversity of scientific disciplines that have come to be associated with the study of plants. Our M.Sc., M.Phil. and Ph.D. programmes are multi-faceted and designed to empower post-graduate students and researchers with a holistic and comprehensive education across a wide range of subject areas, which would enable them to contribute effectively to basic and applied education and research in plant biology. The Department has 25 faculty members and ~270 students.

- *About the programme*

  The M.Sc. – Botany programme includes a wide diversity of courses covering all aspects of Plant Sciences. In addition to unique combinations of basic, advanced and applied courses (as Core and Discipline-Specific Elective papers), the programme also has a strong interdisciplinary component. Emphasis is on experiential learning through hands-on laboratory exercises, field trips and projects. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology. The disciplines studied include plant structure, growth and development, molecular biology, physiology, biochemistry, pathology, ecology, genetics, systematics, evolution, bioinformatics, biostatistics and transgenic technology on a variety of taxa ranging from algae, fungi and other microbes, bryophytes and vascular plants (ferns, gymnosperms and angiosperms including crop plants) at the cellular, organismal, community and ecosystem levels.

- *About Post Graduate Attributes*

  In addition to academic rigor and training in subject-specific areas listed above, our students are also well trained in ethics, critical thinking, reasoning and analytical skills, effective communication, laboratory safety, sensitivity to environment and sustainable living.

- *About the process of course development involving various stakeholders at different stages.*

  The draft course contents were finalized by the Staff Council after extensive deliberations and discussions involving all faculty members in Staff Council Meetings. Feedback from students and alumni was obtained by sending the draft to them. The draft courses were uploaded on the Delhi University website to invite

comments and suggestions from various stakeholders and reviewed by the Staff Council Prior to approval by the Departmental Council, Courses Committee of UG and PG in Botany and then sent to five external experts in the subject area for their critical inputs and suggestions. The finalized course contents were then discussed in Faculty of Science and submitted for administrative approval by the statutory bodies of Delhi University.

II. Introduction to CBCS (Choice Based Credit System)

Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre

(ii) 'Course' means a segment of a subject that is part of an Academic Programme

(iii) 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission

(iv) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre

(vi) 'Open Elective' means an elective course which is available for students of all programmes, including students of same department. Students of other Department will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

III. Master of Science in Botany Programme Details:

Programme Objectives (POs):

The M.Sc. - Botany programme is designed to equip students with essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms and with the ecosystem. Students would also become aware about the social and environmental significance of plants and their relevance to the national economy.

Programme Specific Outcomes (PSOs):

PSO1. A student completing the course is able to understand different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms.

PSO2. The student completing the course is trained in various analytical techniques of plant biology, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

PSO3. The student completing the course is able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, proteomics and transgenic technology. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data.

PSO4. The student completing the course is capable of executing short research projects incorporating various tools and techniques in any of the basic specializations of Plant Sciences under supervision.

Department of Botany, University of Delhi

Programme Structure:

The Master of Science in Botany programme is a two-year course divided into four semesters. A student is required to complete **84** credits for completion of the course and the award of degree.

Part	***Year***	***Semester***	***Semester***
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV

Course Credit Scheme - Consolidated

Semester	**Core Courses**			**Elective Course**			**Open Elective Course**			**Total Credits**
	No. of papers	Credits (L+T/P)	**Total Credits**	No. of papers	Credits (L+T/P)	**Total Credits**	No. of papers	Credits (L+T/P)	**Total Credits**	
I	5	10+0+10	**20**	0	0+0+0	**0**	0	0+0+0	**0**	**20**
II	5	10+0+10	**20**	0	0+0+0	**0**	0	0+0+0	**0**	**20**
III	2	4+0+4	**8**	3	6+0+6	**12**	1	2+0+0	**2**	**22**
IV	0	0+0+0	**0**	5	10+0+10	**20**	1	2+0+0	**2**	**22**
Total no. of Papers and Credits for the Course	**12**	24+0+24	**48**	**8**	16+0+16	**32**	**2**	4+0+0	**4**	**84**

* For each Core and Elective Course, there will be **two** hours of Theory lectures (2 credits) and **four** hours of Practicals (2 credits) per week in a semester (14 weeks).
* Open Electives can be taken for a maximum of 4 credits, one course each in semester III and IV.

* Duration of Theory examination of each paper shall be 3 hours and of Practical examination of each paper shall be 6 hours.
* Each paper will be of 150 marks of which, 70 marks shall be allocated for end-semester theory examination, 30 marks for internal assessment and 50 marks for end-semester practical examination. For Dissertation it will be equivalent to one or two Electives as per the guidelines from Faculty of Science.

Core Courses

Semester I (individually for each semester)				
Number of core courses - 5	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Physiology and Biochemistry	2	2	0	4
Genetics and Cytogenetics	2	2	0	4
Microbiology and Phycology	2	2	0	4
Biology of Archegoniates	2	2	0	4
Plant Systematics	2	2	0	4
Total Credits	10	10	0	20

Semester II (individually for each semester)				
Number of core courses - 5	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Cell and Molecular Biology	2	2	0	4
Evolutionary Biology	2	2	0	4
Developmental Biology of Plants	2	2	0	4
Recombinant DNA Technology and Proteomics	2	2	0	4
Pathogens and Pests of Crop Plants	2	2	0	4
Total Credits	10	10	0	20

Semester III (individually for each semester)				
Number of core courses - 2	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Principles of Ecology and Environmental Science	2	2	0	4
Plant Biotechnology and Resource Utilization	2	2	0	4
Total Credits	4	4	0	8

Elective Courses

	Semester III (individually for each semester)				
	Number of elective courses – <u>Three</u> courses to be selected out of <u>six</u> offered*	Credits in each Elective course			
	Elective Courses	Theory	Practical	Tutorial	Credits
1	Cell and Developmental Biology	2	2	0	4
2	Microbial Technology	2	2	0	4
3	Bioinformatics, Computational Biology and Biostatistics	2	2	0	4
4	Genetics, Genomics and Molecular Breeding	2	2	0	4
5	Algae, Environment and Human Welfare	2	2	0	4
6	Genomics and Proteomics	2	2	0	4
	Total Credits	6	6	0	12

* Please see below for information on Dissertation.

	Semester IV (individually for each semester)	
	Number of elective courses – <u>Five</u> courses to be selected out of ten	

	offered	Credits in each Elective course			
	Elective Courses	Theory	Practical	Tutorial	Credits
1	Topics in Plant Physiology and Biochemistry	2	2	0	4
2	Landscape Ecology	2	2	0	4
3	Agricultural Ecology	2	2	0	4
4	Reproductive Biology of Flowering Plants	2	2	0	4
5	Molecular Interactions of Plants with Symbionts, Pathogens and Pests	2	2	0	4
6	Immunology	2	2	0	4
7	Advances in Archegoniatae	2	2	0	4
8	In Vitro Technologies and Industrial Applications	2	2	0	4
9	Advanced Plant Systematics	2	2	0	4
10	Advanced Evolutionary Biology	2	2	0	4
11	Dissertation*				
	Total Credits	10	10	0	20

*Dissertation will be offered to top 20% of meritorious students as an option in lieu of one or two elective course in Semester IV. This is subject to the limit of one student per teacher who wishes to mentor students during that academic session. At the end of the 4th semester the candidate will submit a dissertation, which will be evaluated by an external examiner along with a viva-voce examination.

Semester III (individually for each semester)				
Number of Open Electives – 3**	Credits in each open elective			
	Theory	Practical	Tutorial	Credits
Climate Change and Ecosystem Function	2	0	0	2
Plant Diversity	2	0	0	2
Plants and World History	2	0	0	2
Total Credits	2	0	0	2

** Offered to students outside the Department of Botany

Semester IV (individually for each semester)				
Number of Open Electives – 3**	Credits in each open elective			
	Theory	Practical	Tutorial	Credits
Sustainable Development	2	0	0	2
Plant Curios – Fascinating Plants	2	0	0	2
Plants for Human Welfare	2	0	0	2
Total Credits	2	0	0	2

** Offered to students outside the Department of Botany

Semester wise Details of Master of Science in Botany Course

List of Elective Course (wherever applicable to be mentioned area wise)

1. Cell and Developmental Biology
2. Molecular Interactions of Plants with Symbionts, Pathogens and Pests
3. Bioinformatics, Computational Biology and Biostatistics
4. Genetics, Genomics and Molecular Breeding
5. Algae, Environment and Human Welfare
6. Immunology
7. Topics in Plant Physiology and Biochemistry
8. Landscape Ecology
9. Agricultural Ecology
10. Reproductive Biology of Flowering Plants
11. Microbial Technology
12. Genomics and Proteomics
13. Advances in Archegoniatae
14. In Vitro Technologies and Industrial Applications
15. Advanced Plant Systematics
16. Advanced Evolutionary Biology
17. Dissertation*

Selection of Elective Courses:

All discipline-specific elective courses (as listed above) would be offered in the relevant semesters (except under unforeseen circumstances leading to physical absence of the concerned faculty member from the Department for the entire semester). Every optional paper would have an upper limit of student number based on the total number of students in an academic semester such that every student is able to select the required number of elective papers in a semester.

Selection of elective courses would be strictly based on merit-cum-choice of students. Merit of the student would be calculated based on the combined total score of the student in the first and second semesters as released by the Examination Branch of Delhi University. Each student would have to mark his/her choice of elective papers from "1….n" for a semester in a form. Selection of elective papers for semester III would be done at the end of semester II while selection of semester IV elective papers would be done towards the end of semester III. Change/Exchange of Elective papers would not be permitted under any circumstances.

Teaching:

The faculty of the Department is primarily responsible for organizing lectures for Master of Science in Botany. The instructions related to tutorials are provided by the respective registering units under the overall guidance of the Department. Faculty from some other Departments and constituent colleges are also associated with lectures and tutorial work in the Department.

There shall be 90 instructional days excluding examination in a semester.

The Department proposes to offer an option of Dissertation in lieu of one or two discipline specific elective papers to the top 20% students (subject to a maximum of 15 students; not exceeding one student per faculty) in order of merit. Merit list would be based on their consolidated performance in semester examinations till the end of semester II. This would provide students with the option of research-based specialization in the subject.

Eligibility for Admissions:

Admission to the Master of Science in Botany is through merit (50% seats) and entrance (50% seats).

1. Merit based admission of students from Bachelor of Science Honors in Botany from University of Delhi with more than 60% aggregate in core and electives.
2. Entrance based admission of students from Bachelor of Science in Botany/BioSciences/Life Sciences from University of Delhi or any other University degree recognized as equivalent with 55% aggregate.

Assessment of Students' Performance and Scheme of Examinations:

1. English shall be the medium of instruction and examination.
2. Assessment of students' performance shall consist of:
   Assignment/seminar and/or written test with 10 marks for each and 5 marks for attendance. (Assessment will be based on Learning Outcomes for the course)

Pass Percentage & Promotion Criteria:

A student will be considered passed a course if she/he secures 40 percent marks in theory and practical.

Part I to Part II Progression:

PASS PERCENTAGE

Minimum marks for passing the examination in each semester shall be 40% in each paper and 45% in aggregate of a semester.

However, a candidate who has secured the minimum marks to pass in each paper but has not secured the minimum marks to pass in aggregate may reappear in any of the paper/s of his choice in the concerned semester in order to be able to secure the minimum marks prescribed to pass the semester in aggregate.

No student would be allowed to avail of more than 2 chances to pass a paper inclusive of the first attempt.

Department of Botany, University of Delhi

PROMOTION CRITERIA

SEMESTER TO SEMESTER: Students shall be required to fulfill the Part to Part Promotion Criteria. Within the same Part, students shall be allowed to be promoted from a Semester to the next Semester, provided she/he has passed at least half of the courses of the current semester.

PART I TO PART II: Admission to Part II of the programme shall be open to only those students who have successfully passed at least 50% papers out of papers offered for the Part I courses comprising of Semester-1 and Semester-2 taken together. However, she/he will have to clear the remaining papers while studying in Part-II of the programme.

Conversion of Marks into Grades:

Grade Points:

Grade point table as per University Examination rule

CGPA Calculation:

As per University Examination rule.

SGPA Calculation:

As per University Examination rule

Grand SGPA Calculation:

As per University Examination rule

Conversion of Grand CGPA into Marks

As notified by competent authority the formula for conversion of Grand CGPA into marks is: Final %age of marks = CGPA based on all four semesters × 9.5

Division of Degree into Classes:

Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.

Attendance Requirement:

Attendance records are maintained by every faculty member separately for theory and practical classes in their paper/s. These are consolidated at the end of the semester to determine the percent attendance and allocation of marks as given below.

No student shall be considered to have pursued a regular course of study unless he/she is certified by the Head of the Department of Botany, University of Delhi, to have attended 65% of the total number of lectures and seminars conducted in each semester, during his/her course of study. Provided that he/she fulfills other conditions, the Head, Department of Botany, may permit a student to the next Semester who falls short of the required percentage of attendance by not more than 10% of the lectures and seminars conducted during the Semester.

Span Period:

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of **four** years from the date of admission to the Part-I/Semester-I of the Master of Science in Botany Programme.

Guidelines for the Award of Internal Assessment Marks: Master of Science in Botany Programme (Semester Wise)

Internal assessment is performed for a maximum score of 30 marks in each paper. Of this, students are evaluated for 25 marks through minor examinations and/or presentations and assignments. Percent attendance in theory and practical classes is used to award students a maximum of 5 marks based on the table given below:

Attendance	Marks
<67%	0
67 – 69.9%	1
70 – 74.9%	2
75 – 79.9%	3
80 – 84.9%	4
85% and above	5

****

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1001

Physiology and Biochemistry

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:

This course aims to educate student on concepts of proteins, enzymes, basic plant signalling mechanisms, sensory photobiology. The course further deals with physiology of nutrient uptake, photosynthesis and nitrogen metabolism.

Course Learning Outcomes:

1. Students will be taught about proteins, their biosynthesis, folding into specific structures, post translational modifications and degradation mechanisms. The course will also teach about catalytic mechanistic of enzymes, its inhibitors and regulation.
2. The students will be learning about the various signal transduction mechnisms in plants. The concept of second messengers, calcium signaling, kinases/phosphatases in plant signaling would be delineated to enhance their grasping power for understanding of different signaling pathways operative in plants. Two component signaling concept would be introduced and extended to plant hormone signaling. Quorum sensing and its potential biotechnological applications should be clear to students after these classes.
3. During the course students will gain knowledge about various mechanisms such as channel or transport proteins involved in nutrient uptake in plants. Further the course will deal with various phytohormones and their role in physiology of growth and development. This course will introduce students to physiological advances in sensory photobiology.
4. Students will gain the knowledge on reproductive strategies in higher plants along with physiology of flowering, molecular and hormonal basis of flowering mechanism.

Contents:

Unit I: Protein structure and Enzymes: Hierarchical structure of proteins; folding; ticketing; degradation; purification, detection and functional characterization; sequence alignments; molecular motors and pumps. Application of principles of thermodynamics in biology; origin and evolution of biocatalytic reactions; enzyme technology; regulation of enzymatic activity;

Unit II: Signal Transduction: Overview, second messengers, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms and their regulation, e.g. simple and hybrid type of two-component sensor-regulator system in bacteria and plants (examples of chemotaxis, osmosensing, ethylene and cytokinin signaling), quorum sensing.

Unit III: Sensory Photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; scotomorphogenesis and photomorphogenesis.

Unit IV: Nutrient Uptake: Apoplastic and symplastic transport mechanisms, role of aquaporins and transporter proteins, structure-function relationship of inward and outward ion channels,

dual action of ATPases/pumps and modulation of their activity, specialized mechanisms for phosphorus and iron uptake, monitoring of ion channel activity;

Unit V: Plant hormones and other growth regulators: Concept of hormones as chemical messengers, techniques for detection and quantitation of plant hormone, classical approaches and use of mutants in understanding hormone actions, hormones in defense against abiotic and biotic stresses, synthetic regulatory compounds and their uses.

Unit VI: Physiology of plants Reproduction: Reproductive strategies in higher plants and their significance. Sexual and non-sexual modes. Flowering as a multi-organ function, floral induction, evocation and development. Regulation of flowering by light and temperature. Role of circadian rhythm. Involvement of hormones.

Suggested Readings:

1. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
2. Davies P J. (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
3. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, U.K.
4. Nelson, D.L., and Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H. Freeman & Co., New York.
5. Taiz, L. and Zeiger, E. (2010) Plant Physiology. 5th Edition. Sinauer Associates, USA.
6. Heldt, H-W. and Piechulla, B. (2010). Plant Biochemistry, 4th Edition. Academic Press, NY. **ISBN:** 9780128102145

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1002

GENETICS AND CYTOGENETICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives: The paper will deal with Mendelian and non-Mendelian inheritance, quantitative genetics, molecular markers and linkage mapping, prokaryotic and eukaryotic genome-structure, gene function and regulation, epigenetics, cytogenetics and crop evolution.

Course Learning Outcomes:

The unit will provide an understanding of

- inheritance of qualitative and quantitative traits.
- allelic and genotypic frequencies and their partitioning between and among populations.
- Factors governing the genetic structure of populations: significance, implications and applications.

The unit will enable the students to learn about

- mapping genes in bacteria
- functional allelism
- gene regulation in prokaryotes: the components and the mechanisms.

The unit will provide an understanding of

- the structure and organisation of different components of the eukaryotic genomes.
- repetitive elements and transposons: types and their significance.

The unit will provide an understanding of

- the different levels at which gene regulation occurs in a eukaryotic cell.
- the various components and mechanisms involved.

The unit will enable the students to learn about

- the use of linkage and recombination frequencies to map genes.
- Molecular markers, types, development and applications.

The unit will provide an understanding of

- morphology of chromosomes and its relevance in genetics.
- chromosomal aberrations and their role in genome evolution with special reference to crop plants.
- evolution of sex chromosomes and their role in sex determination.

The unit will provide an understanding of

- use of cytogenetic and molecular tools for genome analysis.
- concept of gene pools and their relevance in crop improvement.
- Conservation of plant genetic resources and their utilization for crop improvement.

The unit will provide an understanding of

- the basic concepts of epigenetics, the underlying mechanism and inheritance of the epigenetic modifications.
- the tools to study epigenetics..

Contents:

Unit I: **Introduction**- Mendelian vs. non-Mendelian inheritance, quantitative and population genetics.

Unit II: **Microbial genetics:** Viral, bacterial and fungal genetics, fine structure of gene. Prokaryotic gene regulation- operons, genetic switches, CRISPR-cas, sigma factors, small RNAs.

Unit III: Eukaryotic genome: Components- repeat elements, transposons, organization and evolution.

Unit IV: Eukaryotic gene regulation: *cis* and *trans* regulation: promoters, transcription factors, post-transcriptional regulation, role of chromatin and its higher order structure.

Unit V: Genetic mapping in eukaryotes: Linkage and crossing over, molecular mechanism of recombination, molecular markers and construction of linkage maps.

Unit VI: Cytogenetics: Chromosome: structure and nomenclature, centromere and telomere; Sex determination mechanisms, sex chromosome, chromosomal aberrations. Molecular cytogenetics: methods and applications.

Unit VII: Crop genetics: Crop domestication in selected taxa, role of chromosomal aberrations in crop evolution, genome analysis in crop plants. Plant genetic resources and their conservation.

Unit VIII: Epigenetics: Introduction, methylation, histone modifications, epialleles; their inheritance and role in regulation. Tools to study epigenetics.

Suggested Readings:

1. Russel P. J. (2010). iGenetics-A Molecular Approach, Pearson Education Inc.
2. Gardner E. J., Simmons M. J., Snustad D. P. (1991). Principles of Genetics, John Wiley & Sons.
3. Strickberger M.W. (2008). Genetics, Pearson (Prentice Hall).
4. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
5. Allard R. W. (1999). Principles of Plant Breeding, John Wiley and Sons.
6. Singh R. J. (2002). Plant Cytogenetics, CRC Press.
7. Hartwell L. H., Hood L., Goldberg M. L., Reynolds A. E., Silver L. M., Veres R. C. (2006). Genetics-From Genes to Genomes, McGraw Hill
8. Lewin B. (2008). Genes IX, Jones and Barlett Publishers.
9. Hartl D. L. and Jones E. W. (2007). Genetics-Analysis of Genes and Genomes, Jones and Barlett publishers.

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1003

MICROBIOLOGY AND PHYCOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:

This course aims to increase the understanding of the students about the diversity of microoganisms, their classification, structure and growth.

Course Learning Outcomes:

The students will increase the understanding of the students about the diversity of microoganisms, their classification, structure and growth. Develop theoretical and technical skills of basic microbiology (sterilize, isolate, culture, preserve microbes).

Department of Botany, University of Delhi

Contents:

Microbiology

Unit I: Microbiology: Introduction, classification of microorganisms, Classification of bacteria according to Berger's Manual of Determinative Bacteriology. Ultra structure of bacteria and archeabacteria (cell wall, flagella, fimbriae, pilli, slime layer, S-layers; cell membrane; mesosomes, ribosomes, cytoplasmic inclusion bodies and nucleoid). Bacterial nutrition and growth. Genetic recombination and transformation.

Unit II: General properties of viruses, Viral genome; their types and structure, Plant viruses – structure and replication, movement and interaction with plants, Viroids and other sub-viral entities, Cyanophage, Mycophage and Bacteriophage. Life cycle of Bacteriophage

Phycology

Unit III: Introduction to Phycology as a subject, dealing with a polyphyletc group of organisms collectively name as Algae. Diversity of habitat, cell structure, thallus organization and reproduction among algae. Position of algae in two, five, six and eight kingdoms classifications. Features taken into considerations for classification of algae: chemical nature of the stored food, Cell wall composition, presence or absence of motile (flagellate) cells, structure of flagella and flagellar roots, pattern of mitosis and cytokinesis, number of chloroplast membranes, type of life cycle.

Unit IV: Systematics of algae: sub-groups and their interrelationships. Range of form, structure and life cycles of different groups: Prochlrophyta (formerly), Cyanophyta, Glaucophyta, Rhodophyta, Heterokontophyta (Chrysophyceae, Parmophyceae, Sarcinochrysidophyceae,. Xanthophyceae, Eustigmatophyceae, Bacillariophyceae, Raphidophyceae, Dictyophyceae and Phaeophyceae), Haptophyta (= Prymnesiophyta), Cryptophyta, Dinophyta, Euglenophyta, Chlorarachniophyta and Chlorophyta.

Unit V: Economic, ecological and biotechnological importance of algae: historical perspectives, algae as experimental systems and as sources of colloidal polysaccharides, nitrogenous compounds, pharmaceutical and nutraceuticals, biotechnological potential of symbiotic algae, genetic modification of algae and its potential, algae as the most efficient CO_2 fixers, algae for bioremediation and as biofertilizers.

Suggested Readings:

1. Willey, J M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 10th Edition, McGraw-Hill, USA
2. Ingraham R.Y., Wheels J.L. and Painter M.L. (1976). General Microbiology. The Macmillan Press Ltd.
3. Pelczar M.J., Chan E.C.S and Kreig N.R. (1997). Microbiology Tata MacGraw Hill.
4. Molloy, S.R., Jr. Cronan, J.E. and Jones, F. D. (1994). Microbial Genetics, Bartiett Publishers.
5. Garrity, G.M., Boone, D.R. and Castenholz, R.W. (eds., 2001). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 1, Springer-Verlag, New York, NY
6. Brenner, D.J., Krieg, N.R., Staley, J.T. and Garrity, G.M. (eds., 2005). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 2, parts A, B and C, Springer-Verlag, New York, NY.
7. Vos, P., Garrity, G., Jones, D., Krieg, N.R., Ludwig, W., Rainey, F.A., Schleifer, K.-H. and Whitman, W.B. (eds., 2009). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 3, Springer-Verlag, New York, NY.
8. Krieg, N.R., Ludwig, W., Whitman, W.B., Hedlund, B.P., Paster, B.J., Staley, J.T., Ward, N. and Brown, D. (eds., 2010). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 4, Springer-Verlag, New York, NY.
9. Whitman, W.B., Goodfellow, M., Kämpfer, P., Busse, H.-J., Trujillo, M.E., Ludwig, W. and Suzuki, K.-i. (eds., 2012). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 5, parts A and B, Springer-Verlag, New York, NY.
10. Van Den Hoek, C., Mann, D.G. and Jhans, H.M. (1995). Algae: An Introduction to Phycology. Cambridge University Press, Cambridge.
11. Bold, H.C. and Wynne, M.J. (1978). Introduction to the Algae: Structure and Reproduction. Prentice-Hall, Inc., NJ.

12. Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
13. Graham, L.E., Graham, J.M. and Wilcox, L.W. (2009) Algae, 2nd Edition Benjamin Cummings, Calfornia.
14. Sahoo, D. and Seckbech, J. (Eds) (2015). The Algae World. Springer, Dordrecht.
15. Barsanti, L. and Gualtieri, P. (2014). Anatomy, Biochemistry and Biotechnology, 2nd Edition. CRC/ Taylor & Francis, NY.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1004

BIOLOGY OF BRYOPHYTES, PTERIDOPHYTES AND GYMNOSPERMS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 112 Hrs.**

Course Objectives:
The course aims to have understanding of evolutionary diversification of early land plants and morphological and reprioductive inniovations in bryophytes, pteridophytes and gymnosperms.

Course Learning Outcomes:
The students will be learning

1. How the organ formation occur in the early land plants that resulted to diversity of species of "bryophytes", "pteridophytes" and "gymnosperms"
2. What ware the strategies for conduction of water and photosynthates
3. What are the reproductive strategies

Contents:

Unit I: Comparative Morphology and develpmental anatomy of Anthocerophyta, Marchantiophyta and Bryophyta. (4 lectures) and Vegetative and reproductive innovations (2 lecture), Breeding system in bryophytes (1 lecture)

Unit II: Plant substratum relationship (1 lecture), Growth Forms and life strategies (2 lectures), Bryophytes as site indicators (1 lecture). Role of Bryophytes in Ecosystem Dynamics and in global carbon budget (1 lecture), Bryogeography and conservation of bryophytes (2 lectures)

Unit III: Meristem organization and organ diversity in Pteridophytes (2 lecture), Comparative anatomy of vegetative and reproductive organs of Pteridiphytes (2 lectures),

Unit IV: Fern Classification, Biogeography (1 lecture), Diversity of Ferns - an ecological perspective, biogeography (2 lecture), Gametophyte ecology (1 lecture), Nutrient ecology (1 lecture)

Unit 5: Comparative Morphology and develpmental anatomy of Gymnosperms (3 lectures), Reproductive Biology of Gymnosperms (3 lectures), Impact of coniferous forest on human life (1 lecture)

Suggested Readings:

1. Schofield, W.B. (1985). Introduction to Bryology. Macmillan . ISBN, 0029496608, 9780029496602.
2. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to bryophytes. Cambridge University Press, Cambridge .. ISBN 978-0-521-70073-3.
3. Goffinet, B. and Shaw, A. J. (Edited) (2008). Bryophyte biology. 2nd ed. – XIV + 565 pp., Cambridge University Press, Cambridge. ISBN 978-0-521-69322-6.
4. Dyer, A.F. (1979). Experimental biology of ferns. Academic Press
5. Ranker, T.A. and Haufler, C.H. (2008). Biology and Evolution of Ferns and Lycophytes. Cambridge University Press, Cambridge
6. Mehlereter, K., Walker, L.A. and Sharpe, J.M. (2010). Fern Ecology. Cambridge University Press, Cambridge
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International P Limited. Publishers, New Delhi.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1005

PLANT SYSTEMATICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 112 Hrs.**

Course Objectives:
This course aims to add to understanding of the students about the diversity of plants, their Description, Identification, Nomenclature and their classification including recent advances in the field.

Course Learning Outcomes:
The students will learn
1. What do we mean by systematics? What are different components of systematics? Why is systematics important? What are different data sources in systematics?
2. What are different methods of naming plants? What are different principles of nomenclature? Why name changes?
3. What is phylogeny and phylogenetic systematics? Which methods are used in molecular systematic studies? What do mean by DNA barcoding and its practical implications??
4. What are different methods of collecting and preserving plants? What is the importance of maintaining plants in botanic gardens?

Contents:

Unit I: Systematics: Concepts and components; Plant identification: Taxonomic keys, Classification of flowering plants: APG IV classification. Taxonomic evidence: structural and biochemical characters.

Unit II: Botanical Nomenclature: Principles of nomenclature, Scientific names, Ranks, Author citation, Nomenclatural types, Valid publications, Priority of publications, Conservation of names, Name changes, Synonyms.

Unit III: Plant Molecular Systematics: DNA sequence data, Types of sequence data, Sequence alignment, Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining), DNA barcoding and its practical implications.

Unit IV: Plant Collecting and Documentation: Methods of collecting plants, Herbaria and data information systems: Herbarium specimens, Herbarium operations, Data Information Systems; Role of Botanic Gardens in conservation of biodiversity.

Suggested Readings:
1. Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
2. Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
3. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. (2016). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
4. Simpson, M.G. (2010). Plant Systematics. Elsevier, Amsterdam.

5. Stuessy, T.F. (2009). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
6. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. (2014). Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity. Koeltz Scientific Books, Konigstein, Germany.

Department of Botany, University of Delhi

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2001

CELL AND MOLECULAR BIOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of the present course content is to provide a foundation and background in cellular and acellular entities of plants and animals, cell structure in relation to functions, eukaryotic genome structure (including nuclear and organellar), and regulatory mechanisms.

Course Learning Outcomes:
The students will be learning

1. About the acellular entities including infective particles comprising only protein or RNA, which are parasites of plants and/or animals and of the observations/proposals which challenge the established dogmas, such as, cell being the basic unit of life or higher plants are multicellular rather than supracellular, and current state of knowledge about the plant cell structure and their turn over, starting from cell wall to chromatin, in relation to their functions.
2. What are the components of endo-membrane systems and mechanisms governing intracellular trafficking in plant cells?
3. What is the role of plant cytoskeleton and accessory proteins in major cellular processes of plants?
4. What are various components of the eukaryotic nuclear and organellar genome, with special reference to their regulatory role
5. What are the commonly used bioinformatics tool and their principles for analysis of genes, genetic elements and genomes
6. What are the principle mechanisms of genome replication, maintenance, function and regulation of expression?

Contents:

CELL BIOLOGY (14 LECTURES)

Unit I: Infective particles: prions, viroids, cell theory vs. cell body concept, multicellularity vs. supracellularity.

Unit II: Cell Wall: temporal and spatial dynamism in structure, structural and functional roles, in planta and ex planta uses, cell wall biotechnology

Unit III: Biological membranes: from PLP model to Dynamically Structured Mosaic Model

Unit IV: Cytoplasmic components: Endomembrane systems, organellar architecture, protein sorting and vesicular traffic.

Unit V: Biopolymers: Structural and functional aspects of cytoskeleton and associated motor molecules, their role in cell organization and movement; interaction among cytoskeletal elements; genomics, proteomics and bioinformatics of plant cytoskeleton; cytoskeleton in agrobiotechnology.

Unit VI: Nucleus: its components; Nuclear envelope with emphasis on structure and biogenesis of pore complex; Transport and trafficking. Condensation and packaging of DNA in

eukaryotic and prokaryotic chromosome, State of chromatin during transcription and replication, role in gene regulation.

Unit VII: Cell multiplication and turnover: Cell division, cell cycle controls, breakdown of cell cycle control: programmed cell death.

MOLECULAR BIOLOGY: EUKARYOTIC GENOME STRUCTURE AND REGULATION OF EXPRESSION (14 LECTURES)

Unit VIII: Eukaryotic genome and gene structure:

Nuclear genome: Genomic components: Coding (protein /RNA coding) and non-coding regions- 3-D architecture of genome including chromosomal territories; Gene and Promoter structure- Variation in size and distribution of introns and exons, and function; promoter diversity and function; other Cis regulatory elements (enhancers, insulators, silencers; UTRs)

Organellar genome: Structure, organisation, diversity and evolution of mitochondrial and chloroplast genomes; Cross-talk between nuclear and organellar genetic machinery and its implications: Applications of organellar genomics

Unit IX: Computational tools to analyse gene and genome structure: Sequence and structural features of genomic components (protein and RNA coding gene, promoter); Principles and tools of sequence comparison

Replication and regulation of gene expression:

Unit X: DNA replication: Replicative machinery of nuclear and organellar genomes – DNA polymerases and other components; Replicative processesof nuclear and organellar genomes including structural insights, proof reading, fidelity

Unit XI: Transcriptional processes in nuclear and organelle genome: Trans factors, mediator complexes; Transcriptional process in nuclear and organelle genomes: Co-transcriptional and Post-transcriptional processes-Initiation, elongation, termination, polyadenylation, splicing, alternative splicing

Unit XII: Translation and post-translational modificationsin nuclear and organellar genome: Pioneering round of translation; translation and PTMs; **Small RNA in gene regulation**

Suggested Readings:

1. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M. and Roberts, K. (2014). Molecular Biology of the Cell. CRC Press, Taylor & Francis Group, USA.; 1464 pages
2. Karp, J.G. (2007) Cell and Molecular Biology. John Wiley & Sons, USA.
3. Brown, T. A. (2017). Genomes 4. CRC Press, Taylor & Francis Group, USA. 524 pages
4. Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher (Author), Monty Krieger, A., Martin, K.C. (Eds). (2016) Molecular Cell Biology. Freeman & Co., USA.
5. Buchanan, B.B., Gruissem, W. and Jones, R.L (2015). Biochemistry and molecular biology of plants. Wiley Publisher; pages: 1264p
6. Bioinformatics and Functional Genomics, 3rd edition (2015). Wiley-Blackwell Publisher; pages: 1160.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2002

EVOLUTIONARY BIOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of the course is to provide an understanding of the meaning of Dobzhansky's oft-quoted statement, "Nothing in biology makes sense except in the light of evolution."

Course Learning Outcomes:
Students will acquire understanding of:
1. Patterns of biological variation and underlying processes responsible for these patterns.
2. Evolutionary history and methods of study.
3. Processes of evolution and methods of study.
4. Tree thinking (in contrast to group thinking), skills in application.
5. Population thinking (in contrast to typological thinking), skills in application.

Contents:

Unit I: Introduction - Pattern and process components of scientific theories: biological variation and evolutionary change (evidence for evolution). Darwin and Wallace – natural selection, adaptation. Microevolution, macroevolution. Evolutionary history: reading trees, monophyly, Tree of life. Evolutionary trends: maximum parsimony, origin and evolution of traits across life and green plants.

Unit II: The fossil record. Geological fundamentals. Phylogeny and the fossil record. Evolutionary trends. Rates of evolution. The geography of life. Major patterns of distribution. Historical biogeography, phylogeography.

Unit III: The Modern Synthesis: Population Genetics. Forces of evolution: Genetic drift – Sampling error; Mutation. Migration/Gene Flow. Adaptation – Fitness, coefficient of selection. One-locus models, multi-locus models, modes of selection. Non adaptive traits. Molecular evolution. Neutral theory. Molecular clock. Testing for selection. Modes of selection. Pairwise distances and molecular divergence. Molecular models.

Unit IV: Inferring phylogenies. Maximum Likelihood estimation of trees. Gene trees, species trees.

Unit V: Species. Reproductive isolation. Species concepts and processes of speciation. Drivers of speciation. Geographic patterns. Evolutionary mechanisms. Post-zygotic and pre-zygotic isolation in allopatry and sympatry, reinforcement, character displacement. Hybrid speciation, hybrid zones. Adaptive Radiation.

Suggested Readings:

Futuyma, D. J. (1998). Evolutionary Biology (3rd Edition). Sinauer Associates.
Ridley, M. (2003). Evolution (3rd edition), Blackwell.
Page, R. D. M. and Holmes E. C. (1998). Molecular Evolution: A Phylogenetic Approach, Blackwell.
Herron J. C. and Freeman, S. C. (2015). Evolutionary Analysis (5th Edition). Prentice Hall. ISBN-13: 978-0321616678. ISBN-10: 0321616677.
Hall, B. K. and HallgrÃ-msson, B. (2014). Strickberger's Evolution (4th Edition). Jones & Bartlett.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2003

DEVELOPMENTAL BIOLOGY OF PLANTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
Unlike animals, plants are modular and characterized by developmental reiteration of organs in their 'bauplan'. In order to understand this complexity, one has to look into the various aspects of growth, development and reproduction. This course aims at making the students acquainted with the fundamentals and present understanding of the mechanisms associated with development and differentiation of various plant organs.

Course Learning Outcomes:
The students will be learning in
Section A: Growth and Development
1. How does growth in plants differ from that in animals and what are the different types of net works that regulate growth and development?
2. What are the main growing regions of the plant and how these regions maintain their meristmatic identity while forming cells that are determined and ready to differentiate?
3. How do different organs or tissues with specific structures and functions in the plant body formed and what are the key mechanisms that regulate their development?
4. How do the plants form three-dimensional strctures and what are the mechanisms that are responsible for the huge diversity observed in their architecture?

Section B: Reproduction
1. How a shoot apical meristem transforms into an inflorescence and floral meristems and how these domains developmentally maintained?
2. How the male and female germ lines are established and how a variety of tissues coordinate to form gametes?
3. How seed development is accomplished and what are the mechanisms by which rejection reaction occurs during the progamic phase?
4. Is fertilization necessary for a seed to be formed? How does a cross-talk between fertilized egg and central cells lead to embryo and endosperm formation?

Contents:

Section A

Unit I: Key concepts in growth and development, plant growth vs animal growth, Positive and negative regulatory networks; coordination of growth, isotropic and anisotropic growth, polarity, proliferation and termination of growth, Growth and development of three dimensional structures, developmental plasticity (3)

Unit II: Meristems: Different types, RAM, SAM, Cell fate determination, lineage decisions, developmental patterning (3)

Unit III: Differentiation of cells: stomata, trichomes, tracheary elements etc.; Development of organs: organ identity, key regulatory mechanisms in development of size and shape of specific organs such as leaf, stem, shoot etc. (5) ,

Unit IV: Development and evolution of form and its diversity, Plant architecture: growth of main stem and lateral organs, branching pattern and apical dominance, root and shoot architecture, phyllotaxy, determinate and indeterminate growth, (3)

Section B

Unit V: Transition to flowering; formation of inflorescence and floral meristems, maintenance of domains; floral homeotic mutations in *Arabidopsis*, *Antirrhinum* and *Petunia*

Unit VI: Regulation of anther and ovuledevelopment, microsporogenesis andmicrogametogenesis, megasporogenesis andmegagametogenesis, domains of pollen wall, pollen embryogenesis.

Unit VII: Progamic phase, in vitro pollen germination, pollen tube growth and guidance, double fertilization, self-incompatibility mechanisms, incongruity.

Unit VIII: Polarity during embryogenesis, pattern mutants, invitro fertilization, endosperm development, apomixis, polyembryony, somatic embryogenesis.

Suggested Readings:

1. Bhojwani, S.S., and Razdan, M.K. (1996). Plant Tissue Culture: Theory and Practice, Elsevier
2. Beck, C.B. (2010). An Introduction to Plant Structure and Development, II edition
3. Pua, E-C. and Davey, M.R. (2010). Plant Developmental Biology-Biotechnological perspectives
4. Fosket, D.E. (1994). Plant, Growth and Development: A Molecular Approach, Academic Press.
5. Hopkins, W.G. (2006). The Green World: Plant Development, Chelsea House Publication
6. Howell, S.H. (1998). Molecular Genetics of Plant Development, Cambridge University Press.
7. Leyser, O. and Day, S. (2003). Mechanism of Plant Development, Blackwell Press, 241p.
8. Raghavan, V. (1997). Molecular Embryology of Flowering Plants. Cambridge. University Press.
9. Raghavan, V. (2000). Developmental Biology of Flowering Plants, Springer, Netherlands
10. Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Science Publishers.
11. Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A Laboratory Manual, springer Verlag
12. Whitelam, G.C. and Halliday, K.J. (2007). Light and plant development; Blackwell Publishing; 325p; ISBN : 978-1-4051-4538-1
13. Wolpert, L., Jessell, T., Meyerowitz, E., Robertson, E. and Smith, J. (2007). Principles of Development; Oxford, Oxford University Press.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2004

RECOMBINANT DNA TECHNOLOGY AND PROTEOMICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course is designed to provide a contextual and inquiry based learning of modern day advances in the field of recombinant DNA technology and proteomics.

Course Learning Outcomes:
Students will acquire understanding of:
1. Basic principles and modern age applications of recombinant DNA technology and proteomics.
2. Learning molecular and technical skills along with applications of the instrumentation.
3. Designing/conducting experiments and analysing experimental data.
4. Ethics of Recombinant DNA Technology and proteomics.

Contents:

Unit I: Basics of Proteins structure, synthesis and post-translational modifications –
- Introduction to protein structure, Peptide bonds, non covalent forces in proteins.
- Principles of folding; Hydrophilicity, hydrophobicity & amphipathicity in proteins.
- Comparative account of translation in prokaryotes and eukaryotes.
- Major Post translation modifications.

Unit II: Protein Expression and Engineering –
- Overview of over-expression of proteins in heterologous systems: *E. coli*, yeast, baculovirus and mammals.
- Over-expression and purification of proteins in *E. Coli*-Use of vectors and hosts.

Unit III: Protein Extraction and purification techniques –
- History, principles of protein purification based on the properties of proteins using chromatographic techniques and electrophoresis.
- Column chromatography, ion exchange and affinity chromatography.

Unit IV: Proteomics in post genomic era
- Introduction to proteomics, comparative account with genomics and transcriptomics, overview of various techniques available in field and applications.
- Proteome analysis-two dimensional - separation of total cellular proteins isolation and sequence analysis of individual protein spots by mass spectroscopy.
- Applications of Proteomics as a tool for plant genetics, breeding and diversity studies.

Unit V: Basics of Recombinant DNA Cloning
- Introduction to purpose of cloning and concept of vector and insert, commonly used enzymes and their properties in RDT, principle of restriction digestion and its application in cloning, vectors like plasmid, phage, phagemid, cosmid, BAC, PAC and YAC. Introduction to plant viral vectors. Principles of TA cloning, topoisomerase-based cloning, ligation independent cloning, GATEWAY technology and their applications. Methods for selection and screening of recombinant clones, selection and screening of clones (marker genes, reporter genes, positive and negative selection, insertion inactivation, alpha-complementation).

Unit VI: Isolation of gene(s) of interest
- Introduction to the concept of genome and single gene. Methods and principles for isolation of single gene from prokaryotic and eukaryotic organisms. Introduction to the concept of complementation based gene isolation methods, construction and screening of genomic and

cDNA libraries. Screening of libraries for isolation of single gene. Identification of differentially expressed genes and their isolation by differential screening, cold plaque screening, differential display and subtractive cloning.

Unit VII: Polymerase Chain Reaction and Introduction to DNA sequencing

- PCR and its applications. Different modifications of PCRs- gradient, touch up and touch down, nested PCR, TAIL-PCR, Semi quantitative and quantitative PCR, Gene SoEing and Recursive PCR . Different chemistries involved in QPCR and their utility.
- Introduction to the concept of whole genome sequencing. Principles and concepts of Maxam-Gilbert and Sanger sequencing methods. Introduction to Next Generation Sequencing Methodologies.

Unit VIII: Applications and ethics of Recombinant DNA Technology

- Application of recombinant DNA technology, production of medically and agronomically useful recombinant molecules, application of RDT in diagnostic and therapeutic applications. Impact and safety, moral, social, regulatory & ethical issues associated with recombinant DNA

Suggested Readings:

1. Brown, T.A. (2016). Gene Cloning and Analysis: An Introduction. Seventh edition. Wiley-Blackwell Publishing, UK.
2. Dale J.W., Schantz M.V. and Plant N. (2011). From Genes to Genomes: Concepts and Applications of DNA Technology. Third edition. John Wiley & Sons, UK.
3. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Fourth edition. ASM Press, USA.
4. Green, M.R. and Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Fourth edition. CSHL Press, USA.
5. Metzler, D.E. (2003). Biochemistry. Second edition. Academic Press, USA.
6. Primrose, S.B. and Twyman, R.M. (2006). Principles of Genetic Manipulation and Genomics. Seventh Edition. Blackwell Publishing, UK.
7. Voet, D., Voet, J.G. and Pratt, C.W. (2012). Principles of Biochemistry. Fourth edition. John Wiley & Sons, UK.
8. Wilson, K. and Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology, Seventh edition, Cambridge University Press, USA.
9. Daniel, C.L. (2002). Introduction to Proteomics-Tools for New Biology. Humana Press, Totowa, NJ.
10. Twyman, R. (2014). Principles of Proteomics. Second edition. Garland Science, Taylor and Francis group, UK
11. Comai, L., Katz, J. and Mallick, P. (2017) Proteomics-Methods and Protocols, Springer Protocols, Springer New York.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2005

PATHOGENS AND PESTS OF CROP PLANTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to enhance understanding of students in basic concepts of mycology, fungal biology and importance of fungi. Develop skills for handling fungi. The course deals with basic concepts in plant pathology and interaction of plants with herbivores. Introduction to agricultural pathogens and pests of national importance will be accompanied by basic concepts in integrated disease/pest management, and breeding plants for durable resistance against insect pests and pathogens

Course Learning Outcomes:
The students will

1. Understand basic fungal biology, taxonomy of the fungi and major fungal lineages.
2. Gain skills necessary to isolate and handle fungi from nature, and to discern important microscopic characteristics of fungi.
3. Develop functional knowledge on differentiating disease caused by virus, fungi, and bacteria
4. Learn about the biology of major, and emerging pathogens and pests of crop plants
5. Examine advantages and disadvantages of current control practices based on chemical ecology, genetics of plant resistance and breeding including transgenic approaches
6. Combine theoretical and practical knowledge of plant disease and pest management

Contents:

Unit I: **Overview** of Fungi and fungus-like organisms (Myxomycetes, Acrasiomyctes, and Oomyctes), A higher-level phylogenetic classification of the Fungi. **True fungi**: Characteristics and important Genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota.Physiology of fungal growth, reproduction (asexual and sexual), and mating compatibility, Importance and ecological role of fungi.

Unit II: **Plant Pathology**: General concepts, General characteristics of plant pathogenic organisms and pests,. Molecular approaches for the investigation of plant diseases. Control mechanisms based on chemical treatments, biological control and genetic engineering.

Unit III: **Plant interactions with pathogens and pests**: Plant-virus interactions with emphasis on potyviruses and horticultural crops; Plant-bacterial interactions with emphasis on *Erwinia* sp. and potatoes; Plant-fungus interactions with emphasis on *Magnaporthe* sp. and rice; Plant-nematode interactions with emphasis on *Meloidogyne* sp. and tomato; Plant-Insect interactions with emphasis on *Pieris* sp. and crucifers.

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blaclwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
2. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
4. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
5. Sharma, P.D. (2017). Mycology and Phytopathology. Rastogi Publishers, Meerut, India
6. Burchett, S. and Burchett, S. (2018). Plant Pathology, Garland Science, US

7. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). Integrated Pest Management: Potential, constraints and challenges , CABI Press, UK
8. Dhaliwal, G.S. and Arora, R. (1996). Principles of insect pest management, National Agricultural Technological Information Center, Ludhiana, India
9. Recent and seminal articles from scientific journals

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Core-3001

PRINCIPLES OF ECOLOGY AND ENVIRONMENTAL SCIENCE

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to introduce the students to the concepts and principles of ecology, biological diversity, conservation, sustainable development, population, community and ecosystem structure and function, application of these concepts to solve environmental problems.

Course Learning Outcomes:
The students will be learning

1. What are the limiting factors controlling distribution and growth of organisms?
2. What are the characteristics of organisms as population, community and ecosystems?
3. What are the intra- and inter-specific interactions?
4. What are the ecosystem functions?
5. What are applications of ecological knowledge for the benefit of anthropogenic society?

Contents:

Unit I: Environment – the concept and limits; Law of tolerance and Law of Limiting factors, abiotic factors, biotic interactions, biogeographical distributions – ecological equivalents, Phylogeography, The biosphere, biomes and ecological zones, Bioindicators and biomarkers, Environmental pollution and mitigation strategies.

Unit II: Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure, population growth (density dependent and density independent). Metapopulation dynamics, Competition and coexistence, intra-specific interactions, inter specific interactions, scramble and contest competition model, symbiosis, pre-predator interactions.

Unit III: Nature of ecosystem, production, food webs, energy flow through ecosystem, biogeochemical cycles, resilience of ecosystem, ecosystem management. Case studies of climax and disturbed ecosystems. Ecological factors and plant adaptation. Concepts of ecosystem restoration and applications. Biodiversity – assessment, conservation and management, Biodiversity acts and conventions.

Unit IV: Sustainable Development, Natural resource management in changing environment, Molecular ecology and applications in conservation biology, Global climatic patterns and variations over time, climate change and global warming, coping with environmental variations. Environmental Impacts and their assessment.

Suggested Readings:

1. Odum, E.P. (2011). Fundamental of Ecology. 5th Edition. Saunders. ISBN 9780030584145. 613 pages.
2. Real, L.A. and Brown, J.H. (Eds.) (1991). Foundations of Ecology: Classic Papers with Commentaries. The University of Chicago Press. ISBN-10 0-226-70594-3. 904 pages.
3. Chapman, J.L. and Reiss, M.J. (2003). Ecology: Principles and Applications. Second Edition. Cambridge University Press, UK. ISBN 0 521 58802 2. 335 pages.
4. Singh, J.S., Singh, S.P. and Gupta, S.R. (2006). Ecology, Environment & Resource Conservation. Anamaya Publishers. ISBN 978 8188342556. 688 pages.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Core-3002

PLANT BIOTECHNOLOGY AND RESOURCE UTILIZATION

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course would provide students with an understanding of principles and techniques of plant tissue culture, concepts and methods associated with development and analysis of transgenic plants, and their applications in basic and applied research. In addition, students would be exposed to the economic importance and current research paradigms in various categories of commercially cultivated plants.

Course Learning Outcomes:
The students will learn about
1. Concepts, tools and techniques related to *in vitro* propagation of plants.
2. Different methods used for genetic transformation of plants, use of *Agrobacterium* as a vector for plant transformation, components of a binary vector system.
3. Various case studies related to basic and applied research in plant sciences using transgenic technology.
4. Principles and methods used for phenotypic, genetic and molecular analysis of transgenic plants
5. Uses and current research paradigms in various plants of economic value.

Contents:

Unit I. Plant tissue culture – history; concepts of cell differentiation and totipotency; pathways for *in vitro* regeneration: organogenesis, somatic and gametic embryogenesis; protoplast isolation, culture and regeneration; somatic hybridization; Applications: micro-propagation, meristem culture, embryo rescue, synseed production, somaclonal and androclonal variations, cryopreservation and germplasm storage.

Unit II. Principles and methods of genetic transformation – Introduction; direct gene transfer methods: particle bombardment, electroporation, PEG-mediated and floral-dip; marker and reporter genes; *Agrobacterium* biology and biotechnology; plant - *Agrobacterium* interactions; chloroplast transformation.

Unit III. Applications of genetic transformation – case studies on use of transgenic technology for basic studies and crop/plant improvement; phenotypic, genetic and molecular analysis of transgenic plants; factors influencing transgene expression levels; transgene silencing; marker-free transgenics; genome editing for crop improvement; environmental, social and legal issues.

Unit IV. Plant resource utilization – centres of primary diversity and secondary centres of cultivated plants; crop domestication genes; introduction to current research paradigms in major cereals, oilseeds, legumes, medicinal plants, forest trees, non-alcoholic beverages.

Suggested Readings:
1. Adrian, S., Nigel, W.S. and Mark, R.F. (2008). Plant Biotechnology: The genetic manipulation of Plants, Oxford University Press.
2. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
3. Butenko, R.G. (2000). Plant Cell Culture, University Press of Pacific.
4. Davies, P.J. (2004). Plant Hormones, Kluwer Academic Publishers, Netherlands.
5. Halford, N. (2006). Plant Biotechnology - Current and future applications of genetically modified

crops, John Wiley and Sons, England.
6. Wickens, G.E. (2004). Economic Botany: Principles and Practices, Springer, ISBN 978-0- 7923-6781-9.
7. Research articles and review articles related to the course contents provided by faculty during the course**.**

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Elective-3051

CELL AND DEVELOPMENTAL BIOLOGY (ELECTIVE COURSE)

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of the module on cell and developmental biology is to provide a unified perspective (from historical to contemporary) of genome structure and regulatory mechanisms that are encountered during development and adaptive responses. Cellular and molecular processes that regulate of developmental cascades, including epigenetic landscape during vegetative and reproductive development, and adaptation, primarily in plants, would be discussed. Where required for conceptual understanding, knowledge from non-plant systems would also be included. The course would also overview of strategies and methods that are fundamental to understanding these concepts.

Course Learning Outcomes:
The students will be learning about
1. various factors such as genetic, environmental and hormones that govern developmental events
2. cellular processes such as inter-cellular and intra-cellular signal transduction and cross-talks regulating development
3. cell cycle regulation including PCD and senescence
4. molecular and cellular events / processes that regulate meristem development and maintenance; vegetative and reproductive organ development
5. genetic and molecular elements of epigenetic / chromatin and how chromatin re-modelling / epigenetics regulates development and adaptation

Contents:
1. **Regulation of development (10 lectures):**
    a. Positional information and Cell fate; morphogenetic gradient; polarity determination; commitment, differentiation
    b. Genetic (molecular), environmental (light, temperature, gravity etc) and hormonal regulation of basic development processes
    c. Cross talk between various growth regulators
    d. Cell cycle regulation; Cancer v/s plant tumours; Programmed cell death and senescence
    e. Cytoskeleton and signal transduction
2. **Vegetative organ development (6 lectures):**
    a. Comparative account of organization of shoot and root apical meristems.
    b. Regulation of meristem size and maintenance
    c. Lateral organ initiation from root and shoot meristems
3. **Regulation of reproductive organ development (4 lectures)**
    a. Transition from vegetative to reproductive phase
    b. Molecular basis of flower development and its regulation
    c. Fruit and seed development
4. **Chromatin organization, remodeling and development: (8 lectures):**
    a. Small RNA as regulatory molecule; Epigenetic-Role of histones and small RNA in chromatin organisation; RdDM; paramutations, genomic imprinting; gene dosage
    b. Chromatin remodelling-factors, models and processes; Chromatin state during replication and transcription, and inheritance of epigenetics
    c. Epigenetic regulation of developmental processes (vegetative and reproductive processes; stress responses).

Suggested Readings:

1. Beck, C. (2010). An Introduction to Plant Structure and Development. Cambridge University Press, 465pp.
2. Steeves, T.A. and Sussex, I.M. (1989). Patterns in plant development. Cambridge University Press, 405pp.
3. Inz´e, D. (Ed.) (2007). Cell Cycle Control and Plant Development, Blackwell Publishing Ltd. 394pp.
4. Whitelam, G.C. and Halliday, K.J. (2007). Light and Plant Development. Blackwell Publishing Ltd, 350pp.
5. Meyer, P. (Ed.) (2005). Plant Epigenetic. Blackwell Publishing Ltd. 281pp.
6. Leyser, O. and Day, S. (2003). Mechanism in Plant Development. Blackwell Publishing Ltd. 241pp.
7. Timmermans, M. (2010). Plant Development. Academic Press, 480pp.
8. Howell, S.J. (1998). Molecular Genetics of Plant Development. Cambridge University Press, 365pp.
9. Davies, P.J. (ed.) (2010). Plant Hormones: Biosynthesis, Signal Transduction, Action. Springer, Netherlands, 802pp.
10. Karp, J.G. (2007). Cell and Molecular Biology. John Wiley & Sons, USA.
11. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants. Wiley Publisher, 1264pp.
12. Research and review articles on relevant topics

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Elective-3052

MICROBIAL TECHNOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 112 Hrs.**

Course Objectives:
This course aims to increase the understanding of the students about the importance of microbes in argriculture, environment, industry, medical care and their applications. Develop skills for handling microbes. The course deals with biotechnological advances in the field of applied microbiology.

Course Learning Outcomes:
The students will
1. Be able to understand and appreciate role of microbes in their life.
2. Develop theoretical and technical skills of basic microbiology (sterilize, isolate, culture, preserve microbes).
3. Understand the physiological, biochemical and molecular mechanisms underlying the use of microbes in human welfare and environment.

Contents:
Unit I: General Microbiology: Diversity of the microbial world; Microbial nutrition, growth and metabolism

Unit II: Agricultural Microbiology: Agriculturally important microorganisms; Biological nitrogen fixation; Mycorrhizae, microbial mineralization, Biocontrol of plant diseases, Plant growth promoting rhizobacteria (PGPR).

Unit III: Microbes and quality of environment; Distribution and implications of microbes in air – bio-aerosols, microbial flora of water, water pollution, drinking water and domestic waste treatment systems; Microbial pesticides, microbial degradation of pesticides and toxic chemicals, biodegradation of the agricultural residues, bioremediation of contaminated soils. Microbes in nanotechnology, biosensors; Microbes in extreme environments.

Unit IV: Food and industrial microbiology– Fermentation, fermented foods, fermenter design and growth processes, food spoilage, methods of food preservation; Microbes in recovery of metal (bioleaching) and oil, Cell and enzyme immobilization, microbial enzymes of industrial interest; Novel medicines from microbes.

Suggested Readings:
1. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 10th Edition, McGraw-Hill, USA
2. Okafor, N. and Okeke, B.C. (2018). Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, Boca Raton
3. Subba Rao, N.S. (2018). Soil Microbiology, 5th Edition, Medtech, New Delhi
4. Subba Rao, N.S. (2018). Advances in Agricultural Microbiology, 2nd Edition, Medtech, New Delhi
5. Aneja, K.R. (2016). Laboratory Manual of Microbiology and Biotechnology, Medtech, New Delhi.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Elective-3053

GENETICS, GENOMICS AND MOLECULAR BREEDING

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 112 Hrs.**

Course Objectives:
The paper will develop an understanding of the relation between genetics and genomics. It will also help in comprehending how genomic information is related to chromosomes and its usage in developing tools for genetics and molecular breeding.

Course Learning Outcomes:

The unit will provide an understanding of

- genetic and molecular basis of domestication in selected taxa.
- conservation and effective utilization of existing diversity for crop improvement.

The unit will provide an understanding of the various strategies deployed for improvement of crops based on the breeding systems.

Students will also learn about phenomena such as male sterility, apomixes, self-incompatibility and their significance in crop improvement,,

The unit will provide an understanding of

-the different theories that have been proposed to explain heterosis.

- different ways of exploiting heterosis..

Students will learn about

- basis of developing different molecular markers systems.
- Advancements made in the generation of molecular markers including recent developments in post-genomic era.

Students will learn

- the key concepts and methodologies for construction of linkage maps.
- mappingof quantitative traits and association mapping.
- integration of these maps with physical maps and chromosomes.

The students will learn

-how to associate molecular markers with the trait of interest.

- how to integrate molecular methods with conventional improvement strategies to accelerate plant breeding.

Students will learn

- concepts in epigenetics and the mechanisms involved.

-epigenetic regulation of transposable elements and processes involved in phase change such as flowering and vernalization.

Students will learn

-different tools and techniques involved to compare genomes at both micro- and macrolevel.

-to exploit the syntenic relationships among genomes for addressing questions of basic and applied nature including evolutionary relationships.

Contents:

UnitI: Genetics and genomics of crop domestication - Molecular basis of domestication, domestication syndrome, archaeological and molecular evidences, consequences of domestication, genetic erosion. Case studies: maize, tomato, soybean, rice, tea, common bean etc.

Unit II: Genetic systems and breeding methods - Selection and breeding strategies for self-pollinated, cross-pollinated and clonally propagated plants. Self-incompatibility, male sterility, apomixis.

Unit III: Genetics and molecular basis of heterosis - Types of heterosis, genetic and molecular basis of inbreeding and heterosis, utilization in crop improvement.

Unit IV: Molecular markers - Development of molecular markers: trends and progress, RFLP, PCR based, single locus and multi-locus markers, NGS based markers. Applications of molecular markers.

Unit V: Genetic maps - Construction of linkage maps, high-density maps, QTL mapping, association mapping, integration of genetic maps with physical maps/chromosomes.

Unit VI: Molecular breeding - Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), genomic selection, GWAS.

Unit VII: Epigenetics - Genomic imprinting, epigenetic control of plant development, vernalisation and transposable elements, RdDM, role of sRNA.

Unit VIII: Comparative genomics - Tools and techniques, macro- and microsynteny, evolutionary principles, applications.

Suggested Readings:

1. Recent reviews and relevant reading material will be provided to the students for the topics covered in theory as well as in laboratory exercises.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Elective-3054

BIOINFORMATICS, COMPUTATIONAL BIOLOGY AND BIOSTATISTICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course has a strong interdisciplinary component and is designed to equip students with essential skills in bioinformatics (at basic and advanced levels). It will introduce applications of computational biology in diverse areas of biological sciences and provide training in the use of statistics in biological sciences.

Course Learning Outcomes:
1. Students will learn necessary skills in the use of databases and online tools related to biological data.
2. Students will be trained in developing algorithms and write programs for analysis of biological data using PERL.
3. Introduction to Next Generation Sequencing (NGS) technologies and analysis of NGS data.
4. Students will learn about the principles of *in silico* drug design and molecular modeling using online tools.
5. Students will be trained in statistical concepts and principles relevant to biological data and their applications.

Contents:

Unit I : Databases and online tools

Unit II: Fundamentals of computer programming and algorithm development; Programming in PERL for analysis of nucleotide sequences: development of PERL scripts for analysis of sequence length, nucleotide composition, percent GC, generation of complementary and reverse complement sequences, restriction mapping, melting temperature, homology analysis between sequences, translation of mRNA, codon usage analysis.

Unit III: Next Generation Sequencing (NGS) technologies* and introduction to NGS data analysis.

Unit IV: Introduction to *in silico* drug design and molecular modeling.

Unit V : Biostatistics: Conceptual understanding of Statistic and Statistics; Parameters; Variable; Population, Finite and Infinite Populations; Sample; Discrete and Continuous Variations; Samples: Simple random sample, Stratified sample, Clustered samples, Judgment sample, Countable and Uncountable sample; Variables and Attributes; Dichotomous attributes; Estimation: Point estimation, Interval estimation; Confidence Interval; Arithmetic Mean, Median, Mode, Merits and demerits of Mean, Median and Mode; Range; Roles of t – statistic; when and where do we use it, Independent *t* – statistic, Paired *t* – statistic, Two-samples *t* – statistic, One sample *t* – statistic; *F* – statistic; Chi-square test and its uses; "testing" in statistics; Hypothesis, Null hypothesis, Two-sided hypothesis, One-sided hypothesis; Critical region; Level of significance; *P* – value; Standard deviation; Variance

Suggested Readings:
1. Attwood, T.K. and Parry-Smith, D.J. (2004). Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.
2. Edwards, D. (Ed.) (2007). Plant Bioinformatics: Methods and Protocols, Humana Press, New Jersey, USA.

3. Kulas, J.T. (2008). SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.
4. Pagano, M. and Gauvreau, K. (2007). Principles of Biostatistics. Thomson India Edition, New Delhi.
5. Schwartz, R., Phoenix, T. and d Foy, B. (2005). Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.
6. Dwyer, R.A. (2004). Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.
7. Rosenkrantz, W.A. (2009). Introduction to Probability and Statistics for Science, Engineering and Finance. CRC Press, Boca Raton.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT- Elective - 3055

ALGAE, ENVIRONMENT AND HUMAN WELFARE

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to educate students towards advance topics involving algae for Industrial/environmental application and for human welfare. The course also deals with photosynthesis, lipid metabolism, Nitrogen fixation and assimilation in algae.

Course Learning Outcomes:

1. The student will learn about organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electron transport chain which is important for production of ATP with the help of ATP synthase.
2. The students will learn about uptake mechanism(s) of HMs through various transporters present on plasma membrane. They will also learn about how algal cells have various strategy to counter the HMs induced oxidative stress and their negative consequences on vital metabolic occurrences like photosynthesis and nitrogen metabolism.
3. The course teaches about various beneficial products from algae and their industrial production. These include various algae utilized for food, as neutraceuticals or as fuel.

Contents:

Unit I: Photosynthesis advancement in various class of algae **4 lecture**

Organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electron transport chain, proton transport and ATP synthesis, CO_2 assimilation under dark reaction, RUBISCO activity and its interaction with light and oxygen

Unit II: Nitrogen fixation and assimilation in algae: **5 lecture**

GS-GOGAT cycle, GDH cycle, Nitrogenase, Heterocyst differentiation, structural significance, physiological and biochemical adaptation for Nitrogen fixation, NR, NiR, GS, GOGAT, and AspAT enzymes biosynthesis, structure and their functions, nitrogen fixation and photosynthesis-ralationship, nitrate reduction and assimilation in algae, assimilation of organic nitrogen in algae: urea, amino acids and amides.

Unit II1: Tolerance and detoxification mechanisms of HMs in algae: **5 lecture**

Effective methods of culturing the potent algae for efficient phycoremediation of HMs, various methods implied by algae for efficient accumulation of HMs, uptake of HMs by various cell membrane associated transporters, reactive oxygen species, oxidative stress, carbonylation of proteins during HMs stress, metallothionein, antoxidative enzymes: SOD, CAT, APX, GR, DHAR, MDHAR and non enzymatic antioxidants: GSH, AsA, proline, and polyamines.

Unit IV: Algal application for human welfare: **4 lecture**

Algae for food, pigments, antioxidants, proteins and carbohydrate.

Unit V: Algal Lipids, biodiesel and biofuel production **7 lecture**

Fatty acid biosynthesis, Polyunsaturated fatty acid accumulation, Biodiesel production, Biohydrogen, Bioethanol production. Research hurdles and possible solutions.

Unit VI: Biotechnological advancements in algal research: **3 lecture**

Genetic engineering in algae, Mutagenesis for strain improvement, engineering efforts for advancement in culturing techniques, Integrated multitrophic aquaculture.

Suggested Readings:

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Elective-3056

GENOMICS AND PROTEOMICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 112 Hrs.**

Course Objectives:
This course aims to introduce the students to the exciting area of "omics". It is structured in such a manner that the theory, practical and presentations/seminars would provide a complete over-view of the methods of genome and proteome analysis and their significance in understanding biological systems.

Course Learning Outcomes:
Students will acquire understanding of:
1. Basic principles of DNA sequencing and evolution of DNA sequencing from classical Sanger to Next Generation Sequencing. Relevance of genomic variations and their utility.
2. Principle of analysing genome wide gene expression and its utility.
3. Utility of generating mutants with respect to forward and reverse genetics and how these mutants can be used for studying genome wide changes in gene expression.
4. Comparative genomics and its utility in deciphering genome organization of a sequenced genome.
5. Control of gene expression at transcriptional and post transcriptional levels by genome imprinting and formation of heterochromatin by small RNAs.
6. Understand and explain current scenario of plant proteomics including what is proteomics? It's different types, need and limitations.
7. Understand methods/procedures and different tools and techniques applied for proteome analysis.
8. Plan and execute a proteome analysis experiment.
9. Understand application of proteome analysis in plant sciences in particular and in daily life in general.

Contents:

Unit I: Genome sequencing strategies and programs, new technologies for high throughput sequencing, methods for sequence alignment and gene annotation.

Unit II: Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications.

Unit III: Concept of forward and reverse genetics as applied to designing genome wide screens for deciphering gene function. Gene tagging, gene and promoter trapping, knockout and knock-down mutants. Dynamic modulation of protein structure and function. Introduction to comparative genomics of model plants and related crop species.

Unit IV: Introduction to RNAi and gene silencing. Genome imprinting, small RNAs and their biogenesis, role of small RNAs in heterochromatin formation and gene silencing, genomic tools to study methylome, histone modifications and chromatin structure.

Unit V: Analysis of proteins by different biophysical and biochemical methods (CD, circular dichroism, NMR, nuclear magnetic resonance, UV visible and fluorescent spectroscopy. Proteomics-what, why and tools of proteome analysis. Mass spectrometry based protein identification like PMF- protein mass fingerprinting and tandem MS/LCMS. Protein identification and analysis on protein related databases like ExPASy server. Gel based proteome analysis including sample extraction, lysis, resolution on 2D-PAGE, Image analysis including data acquisition, gel matching, master gel, and data analysis.

Unit VI: Gel free methods of proteome analysis (label as well as label free), Comparative proteomics, interactomics, protein chips, arrays and proteogenomics. Future directions and potential applications of proteome analysis.

Suggested Readings:

1. Brown, T.A. (2017). Genomes 4 . CRC Press.
2. Armstrong, L. (2013). Epigenetics. CRC Press.
3. Dale, J.W., Schantz, M.V. and Plant, N. (2011). From Genes to Genomes: Concepts and Applications of DNA Technology. Third edition. John Wiley & Sons, UK.
4. Green, M.R. and Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual. Fourth edition. CSHL Press, USA.
5. Leibler, D.C. (2006). Introduction to Proteomics: tools for the new biology, Humana Press.
6. Walker, J.M. (2005). The Proteomics Protocols Handbook, Humana Press, Totowa, New Jersey, USA

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4051

TOPICS IN PLANT PHYSIOLOGY AND BIOCHEMISTRY

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The course will deal with advance topics on plant growth and development, secondary metabolites and stress physiology.

Course Learning Outcomes:
1. The students will be learning Abiotic stress signaling, stress tolerance/adaptive physiological and biochemical changes focusing on mechanism (s). They should be in a position to extrapolate this knowledge for creating stress tolerance crops.
2. Redox changes in normal growth and development as well as during stress are important. These redox changes decide the fate of plant. Reactive oxygen species (ROS) and Reactive nitrogen species (RNS) are the main players. Students would be able to understand the biosynthesis of these redox species in biological systems as well as the antioxidative defense and significance of these in various physiological functions.
3. Various secondary metabolites from plants and their roles for plant defence as well as human welfare.
4. Physiological, molecular and biochemical basis of the process of seed germination as well as dormancy would prepare the students to manipulate these processes for improvising crop yields in future.
5. Fruit development and ripening is an important aspect of plant development, understanding of this process can help in preventing post harvest losses. Student would acquire a detailed understanding of major regulatory (biochemical/molecular) framework for the process.
6. Students will gain the knowledge on various modes of programmed cell death, molecular biology of PCD and physiological changes that a cell undergoes during these processes.
7. Understanding of sensory physiology would help the students to understand the perception mechanism in plants. An understanding of perception mechanism of different signals would be imparted to students.

Contents:

Unit I: **Stress Physiology: F**reezing, heat, salinity, and **heavy metals stresses in plants**; plant responses to abiotic stresses, mechanisms of abiotic stress tolerance in plants: water deficit, drought, salinity and heavy metals tolerance.

Unit II: **Oxidative and nitrosative stress and antioxidative strategies**: Nitrosative and oxidative stress - causes and effects, nitric oxide biosynthesis and metabolism, NO mediated signaling, markers of nitrosative stress, NO crosstalk with other hormones, cross talk between SA and JA in plants; antioxidants defence mechanism(s) in plants; regulation and functions of ascorbate-glutathione cycle in plants.

Unit III: **Secondary metabolites and chemical defence**: Natural products (secondary metabolites), their range and ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis.Molecular approaches and biotechnological applications.Metabolic engineering in the production of pharmaceuticals.Biochemical mechanisms of plants' chemical war against other plants and animals.Plant responses to herbivory; constitutive defence mechanisms; induced phytochemical responses; biochemical mechanisms of allelopathty.

Unit IV: **Physiology of seed development, maturation, dormancy and germination**: Hormonal

regulation of seed development, events associated with seed maturation, factors regulating seed dormancy, mechanisms of mobilization of food reserves during seed germination.

Unit V: **Fruit development and ripening:** Stages of fruit development and their regulation, biochemical and related events during fruit ripening in chimacteric and non-climacteric fruits, physiology and biochemistry of fruit abscission, post-harvest changes, production of transgenic fruits.

Unit VI: **Programmed cell death (PCD)**: Concept of PCD and its types in plants during vegetative and reproductive stages. Developmental and stress-induced PCD.Plant senescence and its characteristics.Leaf and flower senescence.Altered metabolism during senescence and its regulation.The oxidative stress and the anti-oxidative strategies.Hormonal modulations.Environmental, genetic and molecular regulations.

Unit VII: **Sensory physiology**: Biochemical and biophysical mechanisms of sense of touch, electric self-defence, taste, light, explosion, sleeping and rhythms. Stimuli that trigger rapid movements; movements based on mechanical forces; mobility triggered by sense of touch, taste and electricity; motors driving movements in the living world; actin-myosin motors; photosensing; chemistry of excitability; neurotransmitters in plants.

Suggested Readings:

1. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
2. Davies, P.J. (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
3. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, Oxfordshire, U.K.
4. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry (5^{th}ed.). New York
5. Taiz, L. and Zeiger, E. (2010). Plant Physiology. 5^{th}Edition
6. Heldt, H-W. and Piechulla, B. (2010). Plant Biochemistry. 4^{th} Edition

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4052

LANDSCAPE ECOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to increase the understanding of the students about the diversity of natural and managed landscapes, indices of diversity measurement, spatial and temporal dynamics and landscape management systems

Course Learning Outcomes:
The students will be learning
1. Why and how the diverse landscapes occur in nature and how they are managed by human society?
2. What is the implication of spatial and temporal changes occurring in landscapes?
3. How to monitor the changes occurring in the landscapes?
4. What are the applications of landscape management and landscape ecology?

Contents:

Unit I: Landscapes: the definition, typology, classification and nomenclature; landscape design and management systems; pattern and processes; scale and context

Unit II: Abiotic template; biotic template; Disturbance – meaning, measurement and implications

Unit III: Landscape dynamics; equilibrium and non-equilibrium landscapes; anthropogenic influences; management influences; landscape models – disturbance-succession models; natural range of variability

Unit IV: Pattern and process in landscape ecology; population and community dynamics; landscape genetics; conservation and cultural landscapes – diversity and management

Suggested Readings:

1. Ingegnoli, V. (2002). Landscape Ecology: A Widening Foundation. Springer. ISBN 978-3-642-07663-3 (ISBN 978-3-662-04691-3 (eBook)). 356pp.
2. Turner, M.G. and Gardner, R.H. (2015). Landscape Ecology in Theory and Practice: Pattern and Process. Springer (Second Edition). ISBN 978-1-4939-2793-7 (ISBN 978-1-4939-2794-4 (eBook)). 482pp.
3. Antrop, M. and van Eetvelde, V. (2017). Landscape Perspective: The Holistic Nature of Landscape. Springer. ISBN 978-94-024-1181-2 (ISBN 978-94-024-1183-6 (eBook)), 435pp.
4. Roca, Z., Claval, P. and Agnew, J. (Eds.). (2011). Landscapes, Identities and Development. Ashgate Publishing Limited, England & USA. ISBN 978-1-4094-0554-2. 487pp.
5. Bissonette, J.A. and Storch, I. (2003). Landscape Ecology and Resource Management: Linking Theory with Practice. Island Press. 463pp.
6. Farina, A. (2006). Principles and Methods in Landscape Ecology: Towards a Science of the Landscape. Springer. ISBN -10 1-4020-3328-1 (ISBN-10 1-4020-3329-X (eBook)). 411pp.
7. Agnoletti, M. (Ed.). (2006). The Conservation of Cultural Landscape. CABI. ISBN 10 1 84593 074 6; ISBN 13: 978 1 84593 074 5. 267pp.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4053

AGRICULTURAL ECOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to introduce the students to the application of concepts and principles of ecology to human managed ecosystems.

Course Learning Outcomes:
The students will be learning
1. The meaning of terms agriculture, domestication and selection.
2. What are the ecological principles that are applicable in managed ecosystems such as agriculture systems?
3. The relationship of domesticated biodiversity with its wild biodiversity?
4. How ecological problems influence the agriculture and human food security?

Contents:

Unit I: Agroecology – definitions of terms, scope of the discipline, approaches and viewpoints, domestication, selection and protection of crop plants and farm animals, wild relatives of the crops, ecological experimentation in agriculture.

Unit II: Ecosystem functioning of farming systems – energy and material flows, trophic relations, spatial scales and ecological footprints, organic farming, genetically modified organisms and their implications, climate change – agriculture and adaptation mechanisms.

Unit III: Ecological problems of crop cultivation and solutions – pollution, leakage and erosion, land development, diseases, weeds and pests, chemical, biological and ecological control.

Unit IV: Interactions between farming systems and biodiversity – biodiversity in farming systems, landscape fragmentation, relationships and interdependencies of biodiversity within farming systems with outside farming systems. Case studies of farming systems of India.

Suggested Readings:

1. Gliessman, S.R. (2015). Agroecology: The Ecology of Sustainable Food Systems. CRC Press. ISBN 978 14398956 10; 978 1439895764, 371pp.
2. Altieri, M.A. (2018). Agroecology: The Science of Sustainable Agriculture. Second Edition. CRC press. ISBN 0429975090, 400pp.
3. Gliessman, S.R. (2014). Field and Laboratory Investigations in Agroecology. Third Edition. CRC Press. ISBN 1498728499. 241pp.
4. Wojtkowski, P.A. (2006). Introduction to Agroecology: Principles and Practices. Food Products Press. ISBN-10 1-56022-317-0. 407pp.
5. Alagh, Y.K. (2013). The Future of Indian Agriculture. ISBN 8123767366, ISBN 978 8123767369. 220pp.
6. Mazoyer, M. and Roudart, L. (Translated by Membrez, J.H.). (2014). A History of World Agriculture: From the Neolithic Age to the Current Crisis. Monthly Review Press, New York. ISBN 1-58367-121-8. 527pp.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4054

REPRODUCTIVE BIOLOGY OF FLOWERING PLANTS

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
Reproductive success among the angiosperms is significantly dependent on the innate biology and immediate ecological conditions of plants. The outcome of reproductive effort may vary among different ecological conditions in the same species. This course is meant to answer that how the fitness attributes of plants are influenced by a variety of developmental and ecological constraints.

Course Learning Outcomes:
The students will be learning

1. What are the proximate causes and consequences of transition in the reproductive attributes of flowering plants?
2. What are the theoretical assumptions, and evidences in the evolution of gender in flowering plants?
3. How male sterility in plants is naturally or artificially accomplished, and how the mechanism can be used in yield improvement?
4. What are the different stages of concealment of ovules in angiosperms?
5. Why breakdown in self-incompatibility to self-compatibility does not revert in nature?
6. What are dynamics of plant-pollinator interaction?
7. Does the breeding system analysis in a plant truly indicate the relative contribution of selfing and outcrossing?
8. Why the development of embryo and endosperm is essentially interdependent, and are their exceptions to this interdependence?
9. Why the ratio of flowers to fruit and that of ovule to seed is low in flowering plants?
10. How to differentiate aposporous and sexual modes of reproduction?

Contents:

Unit I: Mechanistic diversity in reproductive modes of flowering plants; transitions in breeding system and pollination modes.

Unit II: Floral contrivances and outbreeding devices, temporal and spatial separation of sex expression, diversity in sexual systems and evolution of dioecy, sex determination mechanisms.

Unit III: Male sterility and its applications for crop improvement, its mechanisms, novel cytoplasms in different crop plants.

Unit IV: Regulation of pistil and ovule development; developmental pathways, gene function and organization.

Unit V: Evolution of self-incompatibility among the flowering plants; signal transduction at the level of stigma style and ovules, double fertilization: origin, mechanism and in vitro fertilization; preferential fertilization.

Unit VI: Floral display, attractants and rewards, pollen load, temporal details and foraging behavior of pollinators, pollination efficiency, physicochemical aspects of pollination; pollination energetics, applied pollination ecology.

Unit VII: Diversity and quantitative estimation of breeding and mating systems; resource allocation; causes of abortion of flower, fruits, ovules and seeds.

Unit VIII: Embryogenesis and embryonic pattern formation; endosperm development and differentiation; ultrastructure and cytology; seed development: pattern, regulation of

gene expression and imprinting; agamospermy and parthenocarpy, pseudogamy and autonomous development of endosperm; Embryo and endosperm culture.

Unit IX: Developmental biology and diversity of fruit types, fruit abortion in relation to resource allocation, dispersal and gene flow.

Suggested Readings:

1. Barrett, S.C.H. (2008). Major Evolutionary Transitions in Flowering Plant Reproduction. Univ. of Chicago Press.
2. Faegri, K. and van der Pijl, L. (1979). The Principles of Pollination Ecology. Pergamon Press, Oxford. 291 pp.
3. Harder, L.D. and Barrett, S.C.H. (2006). Ecology and Evolution of Flowers, Oxford Univ. Press.
4. O'Neill, S.D. and Roberts, J.A. (2002). Plant Reproduction, Sheffield Academic Press.
5. Raghavan, V. (1997). Molecular Embryology of Flowering Plants, Cambridge Univ. Press.
6. Raghavan, V. (2000). Developmental Biology of Flowering Plants, Springer Verlag, New York.
7. Richards, A.J. (1986). Plant Breeding System, George Allen and Unwin, UK.
8. Scott, R.J. and Stead, A.D. (2008). Molecular and Cellular Aspects of Plant Reproduction. Society for Experimental Biology, Seminar Series 55.
9. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Enfield, New Hampshire, U.S.A.: Science Publishers.
10. Shivanna, K.R. and Johri, B.M. (1985). The Angiosperm Pollen: Structure and Function. New Delhi, India: Wiley-Eastern.
11. Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A Laboratory Manual, Springer Verlag, Berlin
12. Shivanna, K.R. and Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual, Springer

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4055

MOLECULAR INTERACTIONS OF PLANTS WITH SYMBIONTS, PATHOGENS AND PESTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives: This paper aims to introduce various aspects of biochemical and molecular interactions of plants with symbionts, pathogens and pests at an advanced level.

Course Learning Outcomes:

The students will

1. Understand plant responses to biotic components of their environments
2. Learn concepts, techniques and applications related to the plant interactions with microbes, pathogens and herbivores

Contents:

Unit I: Introduction to biotic interactions of plants.

Unit II: Recent advances in plant-pathogen and plant-insect interactions: Stages of pathogenesis, Structural and biochemical host defense mechanisms against pathogens and pests, Basal resistance, Non-host resistance, PTI and ETI. Distinction between necrotrophic and biotrophic pathogens, Plant defence against necrotrophs and biotrophs. Systemic acquired resistance, Induced systemic resistance. Induced resistance, signaling pathways, cross-talk between SA and JA-dependent defense responses

Unit III: Genetics, genomics and applications: Genetics, genomics and applications: Gene-for-gene concept, Models for perception of effector proteins by plants, Cloning of resistance genes (R genes) and avirulence genes (Avr genes) from plants and pathogens, Induced responses to herbivory, Genetic engineering for the production of resistance plants to pathogens and pests.

Unit IV: Recent advances in symbiotic interactions with plant with special references to mycorrhizae and root nodule symbiosis.

Suggested Readings:

1. Karban, R. and Baldwin, I.T. (1997). Induced responses to herbivory, Chapter 3, 47-100.Chicago University Press.
2. Hull, R. (2001). Mathew's Plant Virology. Academic Press, NY.
3. Strange, R.N. (2003). Introduction to Plant Pathology. John Wiley & Sons, USA.33
4. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
5. Burchett, S. and Burchett, S. (2018). Plant Pathology. Garland Science, USA
6. Mehrotra, R.S. (2017). Plant Pathology, 3rd Edition, McGraw-Hill Education, New Delhi.
7. Recent and important review articles from scientific journals

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4056

IMMUNOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of this module on immunology is to provide a basic understanding of fundamental of immunology. It will also provide conceptual understanding of the current tools and techniques available in the field of immunology.

Course Learning Outcomes:
The students will be learning about

1. What is immunity and how various factors such as environmental and genetic makeup regulate it, how does immune system evolve?
2. What are antigen and antibodies and how do they interact with each other?
3. What happens at cellular level when a foreign antigen enters body?
4. Various components of immune systems- immunoglobulin, MHC, TCR etc how does body produce them to fight infections?
5. How does body fight infections at cellular level? Mechanism and bimolecular events involved in the process.
6. Immunodeficiency related diseases, transplant rejections, autoimmunity and vaccines

Contents:

Unit I: Fundamentals of Immunology (8 lectures):
Basic principles and overview of immunity, Antigen and antibody production, Cellular interactions in the immune system, Innate immunity, Complement antibody structure and antigen recognition

Unit II: Immunogenetics (8 lectures):
Immunoglobulin genes, Ig/TCR gene rearrangement and generation of diversity, introduction to immunogenetics and the MHC, antigen recognition by T cells, TCR, co-receptors, MHC structure, antigen processing and presentation

Unit III: Immunity in Health and Disease (8 lectures):
Immune response to infectious diseases, immunodeficiency and AIDS, Hypersensitivity, transplant rejections, autoimmunity, Vaccines, Evolution of the immune system

Suggested Readings:

1. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (Eds.) (2012). Kuby Immunology, W.H.Freeman Publishing
2. Research and Review articles on relevant topics

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4057

ADVANCES IN ARCHEGONIATES

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives: The course aims to have undersatnding of adaptive strategies followed during the diversification of land plants, the physiological and molecualar changes, role of species in the ecosystem and their bioprospecting.
Course Learning Outcomes:

The students will be learning

1. What the plant hormones in bryophytes that regulate the growt and development
2. How the bryophytes, pteridophytes and Gymnopsperms interact with the microorganisms What ware the strategies for conduction of water and photosynthates
3. Molecular mechanism of desiccation tolerance and bryophyte and pteridophyte model systems.
4. How the fern gamoetophyte develop in response to habitat conditions
5. What are cases of shrinking popoulation the conservation strategies
6. What are the conditions requiored for germination, growth and development of seed and seedling of conifers.

Contents:

Unit I: Spore germination, protonema development and Hormonal regulation of gametophyte development (2 lectures), Associations Bryophytes with microorganisms and animals (2 lectures), Responses of bryophytes to climate change (1 lecture), Population ecology and population genetics and community ecology (2 lectures), Anispory and sexual dimorphism (1 lecture), Mineral nutrition and substratum ecology (1 lecture), Structure and function of bryophyte dominated Peatlands (1 lecture)

Unit II: Genome sequence and insights into bryophytes biology, evolution, genomics, Model bryophytes for molecular genomic studies (*Physcomitrella patens*), Photoreceptors and photomorphogenesis in *P. patens,* Molecular insights into developmental cascades, Abiotic (dessication tolerance) and bioticstress responsive mechanisms in bryophytes(*Physcomitrella*, *Tortula*)

Unit III: Phenology and habitat spacificity (1 lecture), Fern adaptation to xeric environment (1 lecture), Develeopment of fern gametophyte (1 lecture), Genetics and reproductive biology of ferns (2 lectures), Problem ferns , their impact and managaement (1 lecture), Biology of Azolla (1 lecture), Conservation biology (1 lecture)

Unit IV: Genome sequence and insights into Pteridophytebiology, evolution, genomics, Pteridophytes as model plants (*Ceratopteris*, *Selaginella*), Molecular mechanism of sex determination (*Ceratopteris*), Photoreceptors and photomorphogenesis (*Adiantum*, *Ceratopteris*, *Onoclea*), Stress responsive mechanisms in Pteridophytes (*Selaginella*) Ceratopteris, Trichomanes, Osmunda and Marsilea as model system (1 lecture)

Unit V: Evolution of Pollination mechanism (1 lecture), Seed and seedling biology and regeneration potential (1 lecture), Litter decomposition rate (1 lecture), Conifer plantation as seed trap (1 lecture).

Unit VI: Genome sequence and insights into Gymnosperm biology, evolution, genomics, Micropropagation, somatic embryogenesis, Synthetic seed technology, Acclimatization and adaptive responses of coniferns to environmetnal stresses (1 lecture).

Suggested Readings:

1. Goffinet, B., Shaw, A. J. (Edited) (2008). Bryophyte biology. 2nd ed. – XIV + 565 pp. Cambridge University Press, Cambridge. ISBN 978-0-521-69322-6.
2. Schofield, WB. (1985). Introduction to Bryology. Macmillan . ISBN, 0029496608, 9780029496602.
3. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to bryophytes. Cambridge University Press, Cambridge. ISBN 978-0-521-70073-3.
4. Dyer, A.F. and Duckett, J.G. (1984). Experimental Biology of Bryophytes. Orlando, Academic Press.
5. Dyer, A.F. (1979). Experimental Biology of Ferns. Academic Press
6. Fernández, H., Kumar, A. and Revilla, M.A. (eds.) (2011). Working with Ferns: Issues and Applications, Springer Science+Business Media, LLC20
7. Ranker, T.A. and Haufler, C.H. (2008). Biology and Evolution of Ferns and Lycophytes. Cambridge University Press, Cambridge
8. Mehlereter, K., Walker, L.A. and Sharpe, J.M. (Eds.) (2010). Fern Ecology. Cambridge University Press, Cambridge
9. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International P Limite.. Publishers, New Delhi.
10. Singh, H. (1978). Embryology of Gymnosperms. Encyclopedia of Plant Anatomy. Gebruder Bomtraegro, Berlin.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4058

IN VITRO TECHNOLOGIES AND INDUSTRIAL APPLICATIONS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
To impart theoretical as well as Practical training to the students in the area of *in vitro* technologies used in the different Biotechnology, Agro and Pharma Industries.

Course Learning Outcomes:
The students will be learning

1. What are the different modes of in vitro regeneration? How will you validate the genetic fidelity of regenerants needed for industries?
2. What are the different methods/approaches of genetic transformation and raising transgenics for quality improvement and value addition?
3. What are the technologies involved in the extraction, isolation& characterization of plant-based bioactive compounds useful for pharma industries?
4. What are different methods for elicitation and scaling up of bioactive/therapeutic biomolecules through in technology?
5. What are the current perspectives of different in vitro technologies to the biotech industries?

Contents:

Unit I: Introduction of various in vitro techniques relevant to biotech industries:
Micropropagation (Organogenesis and Somatic embryogenesis) and resource generation of commercially important plant species.
Protoplast isolation, Culture and regeneration; Somatic hybridization and its application for crop improvement through case studies.
Production of virus free plants through meristem culture; Synthetic seeds and cryopreservation for long term germplasm conservation. Embryo rescue technique.
Haploids and their role in crop improvement through case studies.

Unit II: Different methods (direct and indirect) of gene transfer to plants. Genetic transformation of crop plants for improvements of traits such as herbicide, insect-pest resistant plants, Transgenic plants tolerant to abiotic stresses such as , drought, cold, salt and metal. Comparison of I^{st}, 2^{nd} and 3^{rd} generation transgenics and their advantages and constraints.
Transgenic plants with nutritionally rich traits (Value addition traits) such as golden rice, maize, tomato, etc. Edible vaccines, plants with enhanced modified flower pigments.
Genome editing through CRISPR/Cas system

Unit III: Exposures to phytochemical analytical tools such as Principle and working of HPLC, HPTLC, FTIR, LC-MS and GC-MS, Scanning Electron microscopy and Transmission Electron microscopy. Visits to NBPGR and Phytotron Facilities at IARI/ TERI/ and Biotech park based on the existing Institutional facilities

Unit IV: *In vitro* technology and pharma industries. Plant Secondary metabolites, *In vitro* extraction isolation of bioactive compounds from plants used as drugs in pharma industries such as antimalarials e.g. artemisinin, anticancerous, taxol, psoralen, spilanthol, connessine, antidabetics steviosides, rebaudiosides etc. Knowledge of biosynthetic pathways and Elicitation of compounds through abiotic and biotic elicitors, hairy root culture and their scaling up through bioreactors

SUGGESTED READINGS:

1. Herman, E.B. (2008). Media and Techniques for Growth, Regeneration and Storage 2005- 2008. Agritech Publications, New York, USA.
2. Pierik, R.L.M. (1999). In Vitro Culture of Higher Plants. Kluwer Academic Publishers.
3. Prakash, J. and Pierik, R.L.M. (1991). Horticulture - New Technologies and Applications (Current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.
4. George, E.F., Hall, M.A. and De Klerk, G-J. (2008). Plant Propagation by Tissue Culture (3rd Edition), Springer, Netherlands.
5. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
6. Butenko, R.G. (2000). Plant Cell Culture, University Press of Pacific.
7. Davies, P.J. (2004). Plant Hormones, Kluwer Academic Publishers, Netherlands.
8. Halford, N. (2006). Plant Biotechnology - Current and future applications of genetically modified crops, John Wiley and Sons, England.
9. Stewart Jr, C.N. (2008). Plant Biotechnology and Genetics, Principal, techniques and Applications. John Wiley & Sons, USA.
10. Wink, M. (2011). An introduction to Molecular biotechnology. Wiley Blackwell, Germany.
11. Kayser, O. and Quax, W.J. (2007). Medicinal Plant Biotechnology,From Basic Research to Industrial Applications, Vol.I &II. Wiley-VCH, Weinheim
12. Trigiano, R.N. and Gray, D.J. (2011). CRC Press,Taylor & Francis Group, Boca Raton.
13. Ashhara, A., Crozier, A. and Komamine, A. (2011). Plant Metabolism and Biotechnology. John Wiley and Sons, England (UK).
14. Research articles and reviews provided by faculty during the course and review to the important Journals e.g., Nature Biotech., Plant Molecular Biology, Plant Biotechnology Journal, Plant Cell Reports, Plant Tissue Organ Culture, and other journals related to specific topic.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4059

ADVANCED PLANT SYSTEMATICS

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
This course aims to introduce the students to the advanced concepts and principles of taxonomy, evolutionary inference of important morphological characters, biodiversity assessment, important families of flowering plants, their classification and role of important characters and application of standard barcode markers in delineating species boundary.

Course Learning Outcomes:
The students will be learning
1. What is Binomial nomenclature? How it is governed by the ICN?
2. What important morphological characters delineate flowering plants and their classification up-to generic level?
3. What are phylogenetic trees and their importance in modern biology?
4. What is plantbarcoding and role of standard barcode markers used in delineating species?What are the applications of Next generation sequencing in plant systematics?

Contents:

Unit I: Plant systematics: The Components of systematics, Major objectives of systematics;Relevance to society and science.Taxonomic History: Natural systems to cladistics: Natural systems; Phyletic systems;Phenetics; Cladistics.The role of field studies; The role of the herbarium. Botanical Nomenclature: Kinds of names; International Code of Botanical Nomenclature,Names according to rank; Citation of authors; Priority; Type method; Naming a new species;Legitimacy; Synonyms.

Unit II: Introduction to the angiosperms: General characteristics; Evolutionary history; Basalangiosperms and Magnoliids; Basal monocots; Petaloid monocots; Commelinids; Basaleudicots and Caryophyllids; Rosids; Asterids. Classification: The components of classification; Characters and their states; Sources ofcharacters; Evaluation of characters.Systematic evidence: Morphology, Anatomy and ultrastructure; Embryology; Palynology;Cytology; Phytochemistry.

Unit III: Molecular Systematics: Plant genomes: nuclear, mitochondrial, chloroplast; Molecularmarkers; Generating molecular data: restriction site mapping, gene sequencing; Analysis ofmolecular data: alignment of sequences, methods of phylogeny reconstruction.Phylogenetics: The nature of phylogeny; How we depict phylogeny?; The importance ofhomology, Polarizing characters; Rooting Trees; The problem of homoplasy. The plant systematics community: Professional organizations; Work environment; Activities.

Unit IV: Barcoding concept; standard barcode markers: nrDNA, cpDNA and mtDNA. Phylogenomic approach towards understanding plant systematics.

Suggested Readings:

1. Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
2. Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.

3. Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
4. Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. (1999). Molecular Systematics and Plant Evolution. Taylor and Francis, London.
5. Judd. W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. (2002). Plant Systematics: A Phylogenetic Approach. SinauerAssociaes, Inc., Massachusetts.
6. Patané, J.S.L., Martins, J. and Setubal, J.C. (2018). Phylogenomics. In: Setubal J., Stoye J., Stadler P. (eds) Comparative Genomics. Methods in Molecular Biology, vol 1704. Humana Press, New York, NY
7. Simpson, M.G. (2006). Plant Systematics. Elsevier, Amsterdam.
8. Stuessy, T.F. (2008).Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4060

ADVANCED EVOLUTIONARY BIOLOGY

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of this advanced course is to provide students with an evolutionary perspective

Course Learning Outcomes:
Students will acquire the following:
1. Theoretical and practical familiarity with study of evolutionary processes.
2. Theoretical and practical familiarity with study of evolutionary history.
3. Reinforcement of skills in population- and tree thinking.

Contents:

Unit I: Review. Variation - polymorphism; phenotypic, genotypic, reaction norm, phenotypic plasticity. Population Genetics. Genetic drift – Sampling error; Wright-Fisher population, IBD, population structure. Coalescence. Mutation. Migration/Gene Flow. Adaptation. Frequency dependent selection. Balancing selection. Multiple stable equilibria. Fitness landscapes and adaptive peaks. Quantitative traits and response to selection. Punctuated equilibrium.

Unit II: Non-adaptive traits. Sexual selection. Evolution of life histories. Evolution of sex. Levels of selection. Group selection. Conflict and cooperation. Phenotypic models: Optimality theory and ESS.

Unit III: Species concepts and the processes of speciation. Drivers of speciation. Evolutionary mechanisms. Postzygotic and prezygotic isolation in allopatry and sympatry, reinforcement, character displacement. Hybrid speciation, hybrid zones.

Unit IV: Molecular evolution. Neutral theory. Pairwise distances and molecular divergence. Molecular models. Dating phylogenetic events. Genome evolution.

Unit V: Phylogenetic trees, reading and using trees. Inferring phylogenies. Gene trees, species trees. Evolution and development.

Suggested Readings:

1. Baum, D. A. and Offner, S. (2008). Phylogenies and tree thinking. American Biology Teacher 70: 222-229.
2. Futuyma, D. J. (1998). Evolutionary Biology (3rd Edition). Sinauer Associates.
3. Hall, B.K. and HallgrÃ-msson, B. (2014). Strickberger's Evolution (4th Edition). Jones & Bartlett.
4. Herron, J.C. and Freeman, S.C. (2015). Evolutionary Analysis (5th Edition). Prentice Hall. ISBN-13: 978-0321616678. ISBN-10: 0321616677.
5. Nei, M. and Kumar, S. (2000). Molecular Evolution and Phylogenetics. Oxford University Press. ISBN 0 19 513584 9.
6. Page, R.D.M. and Holmes, E.C. (1998). Molecular Evolution: A Phylogenetic Approach, Blackwell.
7. Ridley, M. (2003). Evolution (3rd edition), Blackwell.
8. Zimmer, K. and Emlen, D.J. (2013). Evolution - Making Sense of Life. ISBN 978 1936221172, 978 1936221363

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4061

DISSERTATION

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 112 Hrs.**

Course Objectives:
The objective of this advanced course is to provide students with a hands on training in specialized area of plant sciences

Course Learning Outcomes:
Students will acquire the following:

1. Knowledge on techniques and tools of research
2. Quantitative and qualitative data analysis
3. Analysis and interpretation of data in the perspective of existing knowledge

Contents:
The student will be reading and analyzing the published information in the chosen area of plant science under direct mentoring of a faculty member and will participate in research activity.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3101

CLIMATE CHANGE AND ECOSYSTEM FUNCTION

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives:
This course aims to introduce the students about the facts and issues related to climate change and how it is affecting the ecosystem functions on which the human livelihoods are dependent.

Course Learning Outcomes:
The students will be learning
1. The meaning of terms weather, climate and how variability in weather is distinctly different from climate change.
2. The role of greenhouse gases in supporting life on earth and how anthropogenic activities changed the balance of these gases over time.
3. The past and present climate scenarios and how these information was derived?
4. What are ecosystem functions and how climate change affects them?
5. What the climate models of IPCC indicate?

Contents:

Unit I: Definitions of terms – weather, climate and ecosystem functions. Climate changes over different time scales (evolutionary and current)

Unit II: Drivers of ecosystem function change over temporal scale, abiotic factors and its impact on ecosystem function, anthropogenic disturbances in ecosystem function.

Unit III: Climate change and its consequences for – sea level, rainfall patter, hydrological systems, extreme events, IPCC models and future scenarios.

Unit IV: Expected impacts of climate change on major ecosystem and their consequences for human livelihoods

Suggested Readings:

1. Bonan, G. (2015). Ecological Climatology: Concepts and Applications. Cambridge University Press. ISBN 9781107339200. 692pp.
2. Best, R.J., Stone, M.N. and Stachowicz, J.J. (2015). Predicting Consequences of Climate Change for Ecosystem Functioning: Variation Across Trophic Levels, Species and Individuals. John Wiley & Sons Limited.
3. Post, E. (2013). Ecology of Climate Change: The Importance of Biotic Interactions. Princeton University Press. ISBN 978-0-691-14847-2. 376pp.
4. Smith, T.M., Shugart, H.H. and Woodward, F.I. (Eds.) (1997). Plant Functional Types: Their Relevance to Ecosystem Properties and Global Change. Cambridge University Press. ISBN 0 521 56643 6. 371pp.
5. Romm, J. (2018). Climate Change: What Everyone Needs to Know. Second Edition. Oxford University Press. ISBN 978 0190866105. 300pp.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3102

PLANT DIVERSITY

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives:

The course aims to have understanding of plant diversity, significance of diversity, need of classification, bases of classification, Plant adaptations, distribution of plants, evolutionary diversification.

Course Learning Outcomes:

The students will be learning

1. What is the significance of plant diversity
2. What are the adaptations in plants in relation to habitat conditions
3. Plant diversity at different levels

Contents:

Unit I: Plant diversity and Classification, Levels of biodiversity, various Phyla of Plants and their characteristics (Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms),

Unit II: Ecosystem services, Human Food and Plant diversity, Bacterial diversity, Terrestrial Plant diversity, Marine Plant diversity, Inland water diversity, Rain Forest ecosystem and plant diversity, Landscape diversity,

Unit III: Biodiversity Hotspots, Keystone species, Threats to Plant diversity, Deserification, Endangered plants, Plant invasions, Loss of Plant diversity, Plant Restoration

Unit IV: Indigenous people and plant diversity, Traditional plant conservation practices, Plants in Indian tradition and culture, Plant animal interactions,

Unit V: Use and Economic values of plant diversity, Tourism and Plant diversity, Climate change and plant diversity

Suggested Readings:

1. Kumar, U. and Sharma, A.K. (2001). Plant biotechnology and Biodiversity conservation. Agrobios, Jodhpur.
2. Dobson, A. (1996). Conservation and Biodiversity. Palgrave MacMillan
3. Levin, S.A. (2001). Encylopedia of Biodiversity Vol 1 to 5. Academic Press New York
4. Groombridge, B. and Jenkins, M.D. (2002). World Atlas of Biodiversity, Earth living resources in the 21st Century. University of California Press
5. Singh, J.S., Singh, S.P. and Gupta, S.R. (2008). Ecology, Environment and Resource conservation. Anamaya Publications ,New Delhi
6. Krishnamurthy, KV. (2003). Text Book of Biodiversity. Science Publishers

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3103

PLANTS, PEOPLES AND WORLD HISTORY

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives: An understanding of the ancient history of photosynthetic and terrestrial life and history of plant use by humans.

Course Learning Outcomes:
The students will learn about the historical interactions between plants and humans and their roles in the politics, social and cultural life of humans which will help them to understand the present and predict the future and prepare for it.

Contents:

Unit I: **Early plants and their role in earths' history:** Origin of plants; plants as geoengineers of early atmosphere; role of early plants in biogeochemical cycles, evidences and counter arguments

Unit II: **Plants and earths early landscape :** Evolution of trees; first forests and their role in global climate change; where and how the first grasslands formed, plants and water bodies

UNIT III: **Taming of wild plants by man:** Beginning of Agriculture- when, where and how; Story of transforming wild plants to modern day crops; Role of plants in evolution of human civilization; Influence of plants on language, religious and cultural practices, folklore, fine arts etc and vice-versa

UNIT IV: **Plants in trade and human migrations:** plants/ plant groups that affected human settlements such as wheat, rice, sugarcane, spices, tea, cotton, potato, rubber, narcotic plants etc.

UNIT V: **Plants and Politics**: Specific plants/plant related issues and politics; Amaranths in indigenous civilizations of Mesoamerica and Spanish invasion- consequences, Vavilov vs Lysenkism; Indigo revolt and origin of India non-violent struggle for independence, Chipko movement

UNIT VI: **Genetically Modified Plants**: Plants with genes from other plants/organisms; contentious issues, apprehensions and fears- myths or reality; market forces vs scientific logics; Who decides who decides?

UNIT VII: **Plants of future and future of plants:** Super domestication, synthetic plants, Novel uses of plants, New crop plants- permaculture, edible weeds; Vertical agriculture Plants as candidates for colonization of other planets, plants in bioterrorism and biosecurity

Suggested Readings:

1. Laws, B. (2015). Fifty Plants that Changed the Course of History. Firefly Books.
2. Fowler, C. (1991). The Threatened Gene : Food, Politics, and the Loss of Genetic Diversity James Clarke & Co Ltd.
3. Ladizinsky, G. (1998). Plant Evolution under Domestication. Kluwer. ISBN 978-0412822100.
4. Zohary, D. Hopf, M. and Weiss, E. (2012). Domestication of Plants in the Old World: The Origin and Spread of Domesticated Plants in Southwest Asia, Europe, and the Mediterranean Basin. Oxford: Oxford University Press. ISBN 978-0-19-954906-1
5. Anderson, D., Goudie, A.D. and Parker, A. (2013). Global Environments Through the Quaternary: Exploring Environmental Change. Oxford University Press. p. 283. ISBN 978-0-19-969726-7.

6. Sidney, M. (1986). Sweetness and Power: The place of sugar in Modern History, Penguin ISBN 978-0-14-009233-2.
7. Pieroni, A. and Vandebroek, A.I. (2007). The Ethnobiology and Ethnopharmacy of Human Migrations. ISBN 978-1-84545-373-2
8. Office of International Affairs (1989). Lost Crops of the Incas: Little-Known Plants of the Andes with Promise for Worldwide Cultivation. nap. *edu*. p. 92. ISBN 030904264X.
9. Zabel, P., Bamsey, M., Schubert, D. and Tajmar, M. (2016). Review and analysis of over 40 years of space plant growth systems. Life Sciences in Space Research 10: 1-16.
10. Gaudet, J. (2015). Paprys: The plant that changed the World: From Ancient Egypt to Todays ware wars. Pegasus.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Open Elective-4101

SUSTAINABLE DEVELOPMENT

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives:
This course aims to introduce the students about the concept of sustainable development, how it was interpreted over time for various situations and the measures of sustainable development at community and nation.

Course Learning Outcomes:
The students will be learning
1. The theory of tragedy of commons and definition of sustainable development in various contexts
2. The challenges for achieving sustainable development
3. The global environmental issues and their impact
4. The measure and indicator of sustainable development at community, nation and global level

Contents:
Unit I: From Malthus to Sustainable Development; population, resources, environment and sustainability.
Unit II: Challenges of sustainable development – factors, linkages, determinants and case studies
Unit III: Global environmental issues – population, livelihoods, energy; valuing nature services; global issues
Unit IV: Indicators of sustainable development – sustainable community indicators; global indicators

Suggested Readings:
1. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Earthscan. ISBN 978 1 84407 521 4. 416pp.
2. Egelston, A. (2013). Sustainable Development: A History. Springer. ISBN 978 94 007 4877 4. 117pp.
3. Roorda, N. (2012). Fundamentals of Sustainable Development. Routledge. ISBN 978 1 138 09265 5. 382pp.
4. Ramakrishnan, P.S. (2001). Ecology and Sustainable Development. National Book Trust, Delhi. ISBN 978 8123736228. 198pp.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Open Elective-4102

PLANT CURIOS – FASCINATING PLANTS

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives:
The course aims to have understanding of strange plants with respect to their habitate morphology, functions.

Course Learning Outcomes:
The students will be learning
1. What are the strategies of plants to survive in extreme conditions
2. What are morphological modifications, adaptation on plants

Contents:

Unit I: Plants of extreme conditions, Welwitschia, Podostemads, mosses, conifers, Cacti, Seaweeds, Orchids, *Cordiceps*

Unit II: Plants of unique morphology, *Amorphophallus , Rafflesia arnoldii . Cleistocactus , Dracaena, Hydnora , Victoria amazonica, Populus tremuloides,* Buttercup
Plant ages and size, *Lomatia tasmanica, Pinus sylvestris , Seqiuoiadendron, Sequoid sempervirens, Euphorbia obesa, Wolffia*

Unit III: Plants of unique functions, Insectivorous plants, *Dionaea, Nepenthes, Drosera, Utricularia, Codariocalyx motorius*. Dancing Grass (*Desmodium gyrans*), *Mirabilis* , Baobab (*Adansonia*), *Selaginella lepidophylla*, Skunk Cabbage, Parasitic Plants

Unit IV: Defence strategies of plants, *Lithops* species, *Dracunculus vulgaris* Himalayan Blackberry, *Hippophae*, Poisonous plants, Giant Hogweed, Angel Trumpet, Amanita, Death Camas, Gympie-Gympie, Tree Nettle, Spurge Hogweed, Red Tide Algae, Invasive plants

Unit V: Strange pollination mechanisms, Rare plants, Plant efficiencies, *Ficus*, Palms , *Acacia*, Neem, Plant in Worship, Myths

Suggested Readings:

1. Raven, P.H., Evert, R.F. and Eichhorn, S.E. (2005). Biology of Plants (7th ed.). New York: W. H. Freeman and Company
2. Sakai, A. and Larcher, W. (Eds.) (1987). Frost Survival of Plants. Springer-Verlag, New York NY. 321pp.
3. Kochhar, S.L. (2016). Economic Botany: A Comprehensive Study. Cambridge University Press.
4. Trewavas, A. (2003). Aspects of plant intelligence. Annals of Botany. 92 (1): 1–20.
5. Prance, G.T. (2001). Discovering the plant world. Taxon, 50 (2, 4): 345–359.
6. Acharya, D. and Shrivastava, A. (2008). Indigenous Herbal Medicines: Tribal Formulations and Traditional Herbal Practices. Jaipur, India: Aavishkar Publishers
7. Anderson, E.F. (2001). The Cactus Family. Pentland, Oregon: Timber Press.
8. Bold, H.C. (1977). The Plant Kingdom (4th ed.). Englewood Cliffs, NJ: Prentice-Hall.
9. Capon, B. (2005). Botany for Gardeners (2nd ed.). Portland, OR: Timber Publishing.
10. Cousens, R. and Mortimer, M. (1995). Dynamics of Weed Populations. Cambridge: Cambridge University Press.
11. Herrera, C.M. and Pellmyr, O. (2002). Plant Animal Interactions: An Evolutionary Approach. Hoboken, NJ: Blackwell Science.
12. Mauseth, J.D. (2012). Botany: An Introduction to Plant Biology (5th ed.). Sudbury, MA: Jones and Bartlett Learning.

13. Proctor, M. and Yeo, P. (1973). The Pollination of Flowers, New Naturalist series. London: Harper Collins.
14. Starr, C. (2009). The Unity and Diversity of Life (AP ed.). Belmomt, CA: Brooks/Cole, Cenpage Learning.

Department of Botany, University of Delhi

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Open Elective-4103

PLANTS FOR HUMAN WELFARE

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 28 Hrs.**

Course Objectives:
The course aims to introduce the plant resources that help human society to sustain and benefit from their use.

Course Learning Outcomes:
The students will be learning

1. What are the useful plants to human society
2. What are identification feature of such resources

Contents:
Unit-I
A general overview of economically important plants and their role in human welfare as food, oil, drugs, nutraceuticals, beverages, fibre, timber, biofuels, ornamental and as environment protection through carbon sequestration.

- **Food crops: Cereals; Origin, cultivation and food values of important crops e.g.,**wheat, rice, maize, grain legumes (Pulses), studies pertaining to their improvement through breeding and genetic engineering.
- **Sugars:** morphology, processing of sugarcane and improvement in productivity, by-products and their management for generation of ethanols and electricity. Sources of alternate source of sugars.
- **Spices and condiments:** important spices, structure and their economic values.
- **Alcoholic and non-alcoholic beverages:** Tea, coffee, types, processing, uses and improvement.

UNIT-II

- **Medicinal and nutraceuticals:**
- Traditional plants as source of drugs used against several serious diseases such as cancer, diabetes, malaria, dengue, psoriasis,etc. Plant secondary metabolites; classification, roles in human welfare with reference to case studies; knowledge of extraction, isolation and characterization of bioactive metabolites; elicitation of secondary metabolites from anticancerous plants such as *Podopyllum, Taxus, Cathranthus, Psoralia, Nardostachys, Piper;* antimalarial plants e.g., *Artemisia, Spilanthes, Holarrhena,* etc, and antidiabetics such as *Stevia, Gymnema, Momordica, Azadirachta,etc*: Edible vaccines
- Nutraceuticals and functional foods; Important plants such as *Aloe vera, Moringa, piper* spp. *Aspargus, Withania, Ginseng, Plantago, Amaranthus, Mentha,* blue berries, nuts, etc. yielding antioxidants and nutraceutical compounds.
- Nutritionally rich GM plants such as golden rice, Tomato, etc.

UNIT-III

- **Edible and non-edible oils:** Classification of oils, Oil yielding plants, processing and purification of different edible oils such as mustard, olive, sunflower oil, safflower peanut oil; transgenic approaches and constraints for improvement in different oils.
- Non-edible oils; such as Jojoba (*Simmondsia chinensis), Sesamum indicum* oil, Linseed oil, *Eucalyptus* oil, *Citrus* oil, etc.
- Essential oils; Lavender oil, rosemary oil, almond oil, clove oil cinnamomum oil, etc.
- **Plant-based biofuels e.g.,** Difference between first and 2nd generation biofuels, *Jatropha, Pongamia, Zea mayze, Madhuca, etc.* Extraction and economic viability; application as alternate source of diesels.

UNIT-IV

- **Plants as a source of timber**: e.g., *Tectona grandis, Salix* sp., *Dalberia sisso* (sheesham) and fuel wood, type and resources.
- **Fibre yielding plants:** Cotton (*Gossypium* sp.), Jute (*Corchorus* sp.), sun-hemp (*Crotalaria* sp.) with special reference to current advances pertaining to their improvement through breeding and genetic transformation e.g., Bt cotton.
- **Plants used for Horticulture, floriculture & ornamental values**: Brief introduction of different type of horticultural and ornamental plants (carnation, anthurium, orchids,etc.) and their commercial aspects; recent development of novel varieties through grafting, breeding and genetic transformation for pigment modification.

SUGGESTED READINGS: