UNIVERSITY OF DELHI

MASTER OF SCIENCE - BOTANY

(M.Sc. (Bot))

(Effective from Academic Year 2019-20)

PROGRAMME BROCHURE

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

Executive Council on YYYY, 2018

CONTENTS

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 Study (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, systematics, physiology, biochemistry, molecular biology, recombinant DNA technology, genomics and proteomics, pathology, ecology and environment, genetics and plant breeding, evolutionary biology, 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 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. 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 Undergraduate and Postgraduate studies in Botany and then sent to sixty one 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 students to choose courses from the prescribed list, 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 marking 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 enables potential employers in assessing the performance of the candidates.

Definitions:

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

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

(iii) 'Programme Structure' is a list of courses (Core, Elective, Open Elective) that constitutes 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 and eligibility criteria for admission.

(iv) 'Core Course' is a course that all students admitted to a particular programme will have to study and successfully complete to receive the degree.

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

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

(vii) 'Credit' refers to 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' is the 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 combined together.

(x) 'Grand CGPA' is calculated in the last year of the course by combining the CGPA of two years, i.e., four semesters. Grand CGPA is given in the form of a Transcript. For the benefit of students, a formula for conversation of Grand CGPA into percentage marks is provided 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 within the ecosystem. Students would also become aware of 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, cell & 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.

Programme Structure:

The Master of Science in Botany programme is a two-year course divided into four semesters. A student is required to earn/obtain **100** 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	4	16+00+08	**24**	0	0+0+0	**0**	0	0+0+0	**0**	**24**
II	4	16+00+08	**24**	0	0+0+0	**0**	0	0+0+0	**0**	**24**
III	4	16+00+08	**24**	0	0+0+0	**0**	1	4+0+0	**4**	**28**
IV	0	0+0+0	**0**	4	16+0+08	**24**	0	0+0+0	**0**	**24**
Total no. of Papers and Credits for the Course	**12**	48+0+24	**72**	**4**	16+0+08	**24**	**1**	4+0+0	**4**	**100**

*For each Core and Elective Course, there will be **Four** hours of Theory lectures (4 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 in semester III.

* 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. Dissertation will be equivalent to one discipline-specific elective.

Core Courses

Semester I (individually for each semester)				
Number of core courses - 4	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Physiology and Biochemistry	4	2	0	6
Microbiology and Phycology	4	2	0	6
Biology of bryophytes, pteridophytes and gymnosperms	4	2	0	6
Plant Systematics	4	2	0	6
Total Credits	16	8	0	24

Semester II (individually for each semester)				
Number of core courses - 4	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Evolutionary Biology	4	2	0	6
Developmental Biology of Plants	4	2	0	6
Recombinant DNA Technology and Proteomics	4	2	0	6
Pathogens and Pests of Crop Plants	4	2	0	6
Total Credits	16	8	0	24

Semester III (individually for each semester)				
Number of core courses - 4	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
Principles of Ecology and Environmental Science	4	2	0	6
Plant Biotechnology and Resource Utilization	4	2	0	6
Genetics and Cytogenetics	4	2	0	6
Cell and Molecular Biology	4	2	0	6
Total Credits	16	8	0	24

Elective Courses

Semester IV					
	Number of elective courses – <u>Four</u> courses to be selected out of <u>sixteen</u> offered*	Credits in each Elective course			
	Elective Courses	Theory	Practical	Tutorial	Credits
1	Cell and Developmental Biology	4	2	0	6
2	Microbial Technology	4	2	0	6
3	Bioinformatics, Computational Biology and Biostatistics	4	2	0	6
4	Genetics, Genomics and Molecular Breeding	4	2	0	6
5	Algae, Environment and Human Welfare	4	2	0	6
6	Genomics and Proteomics	4	2	0	6
7	Topics in Plant Physiology and Biochemistry	4	2	0	6
8	Landscape Ecology	4	2	0	6
9	Agricultural Ecology	4	2	0	6
10	Reproductive Biology of Flowering Plants	4	2	0	6
11	Molecular Interactions of Plants with Symbionts, Pathogens and Pests	4	2	0	6
12	Immunology	4	2	0	6
13	Advances in Archegoniatae	4	2	0	6
14	In Vitro Technologies and Industrial Applications	4	2	0	6

15	Advanced Plant Systematics	4	2	0	6
16	Advanced Evolutionary Biology	4	2	0	6
	Dissertation*				6
	Total Credits				24

* Please see below for information on Dissertation.

* The top 20% of students in the merit list drawn on the basis of grades/scores obtained in Semester I and II will have an option of opting for Dissertation, which would provide students with the option of research-based specialization in the subject, in lieu of one 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 presentation and viva-voce examination.

Open Elective courses

Semester III (individually for each semester)				
Number of Open Electives – one to be selected out of the six offered**	Credits in each open elective			
	Theory	Practical	Tutorial	Credits
Climate Change and Ecosystem Function	4	0	0	4
Plant Diversity	4	0	0	4
Plants, People and World History	4	0	0	4
Sustainable Development	4	0	0	4
Plant Curios – Fascinating Plants	4	0	0	4
Plants for Human Welfare	4	0	0	4
Total Credits	4	0	0	4

** Offered to students from outside the Department of Botany

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 IV 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 discipline specific elective paper to the top 20% students only (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 Admission:

Admission to Master of Science in Botany programme 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:
   Assignments/seminars and/or written tests with 10 marks for each and 5 marks for attendance. (Assessment will be based on Learning Outcomes for the course)

Pass Percentage & Promotion Criteria:

Part I to Part II Progression:

PASS PERCENTAGE

Minimum marks for passing the examination in each semester shall be 40% in each paper/course 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 two chances to pass a paper inclusive of the first attempt.

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 50% 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% of the papers offered for the Part I courses comprising Semester-1 and Semester-2 papers 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 into various classes based on CGPA obtained as notified in Examination policy of the University of Delhi.

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/practicals 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/practicals 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 evaluated 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

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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: 128 Hrs.**

Course Objectives:

This course aims to educate student on concepts of proteins, enzymes, basic plant signaling 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 mechanisms 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.

Teaching Plan*:

Week 1: Lecture 1 – Protein structure and Enzymes
Lecture 2 – Protein structure and Enzymes
Week 2: Lecture 3 – Protein structure and Enzymes
Lecture 4 – Protein structure and Enzymes
Week 3: Lecture 5 – Protein structure and Enzymes
Lecture 6 – Physiology of plant Reproduction
Week 4: Lecture 7 – Physiology of plant Reproduction
Lecture 8 – Physiology of plant Reproduction/**1st Internal test**
Week 5: Lecture 9 – Signal Transduction
Lecture 10 – Signal Transduction
Week 6: Lecture 11 – Signal Transduction
Lecture 12 – Signal Transduction
Week 7: Lecture 13 – Signal Transduction
Lecture 14 – Plant hormones and growth regulators
Week 8: Lecture 15 – Plant hormones and growth regulators
Lecture 16 – Plant hormones and growth regulators
Week 9: Lecture 17 – Plant hormones and growth regulators
Lecture 18 – Sensory Photobiology
Week 10: Lecture 19 - Sensory Photobiology
Lecture 20 – Sensory Photobiology
Week 11: Lecture 21 – Sensory Photobiology

Lecture 22 – Sensory Photobiology
Week 12: Lecture 23 – **2nd Internal examination**
Lecture 24 – Nutrient Uptake
Week 13: Lecture 25 – Nutrient Uptake
Lecture 26 – Nutrient Uptake
Week 14: Lecture 27 – Nutrient Uptake
Lecture 28 – Nutrient Uptake

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
2	The students will be learning about the various signal transduction mechanisms 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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
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	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

	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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1002

MICROBIOLOGY AND PHYCOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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).

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 sub-viral particles , Bacteriophages, mycophages and cyanophages: features and economic importance; Breeding for virus resistance, natural mechanisms and transgenic strategies, relevance to Indian agriculture.

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 (Two Lectures).

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 (Eight Lectures).

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 (Four Lectures).

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). Algae: Anatomy, Biochemistry and Biotechnology, 2nd Edition. CRC/ Taylor & Francis, NY.
16. Plant Virology (2014) by Roger Hull; Elsevier/Academic Press, fifth edition, ISBN: 9780123848710

Teaching Plan:

Week 1	Lecture 1	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.
Week 2	Lecture 2	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
Week 3	Lectures 3, 4	Systematics of algae: sub-groups and their interrelationships. Range of form, structure and life cycles of different groups: Prochlrophyta (formerly), Cyanophyta, Glaucophyta,
Week 4	Lectures 5-7	Rhodophyta, Heterokontophyta (Chrysophyceae, Parmophyceae, Sarcinochrysidophyceae,. Xanthophyceae, Eustigmatophyceae, Bacillariophyceae, Raphidophyceae, Dictyophyceae and Phaeophyceae),
Week 5	Lectures 8-10	Haptophyta (=Prymnesiophyta), Cryptophyta, Dinophyta, Euglenophyta, Chlorarachniophyta and Chlorophyta
Week 6	Lectures 11,12	Economic, ecological and biotechnological importance of algae: historical perspectives, algae as experimental systems and as sources of colloidal polysaccharides, nitrogenous compounds, pharmaceutical and nutraceuticals,

Week 7	Lectures 13, 14	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
Week 8:	Lecture 15 – Introduction to Microbiology and classification	
	Lecture 16 – Classification of bacteria	
Week 9:	Lecture 17 – Ultrastructure of bacteria and archeabacteria	
	Lecture 18 – Ultrastructure of bacteria and archeabacteria	
Week 10:	Lecture 19 – Bacterial nutrition and growth	
	Lecture 20 – Genetic recombination and transformation	
Week 11:	Lecture 21 – Viral genome, their types and structure	
	Lecture 22 – Plant viruses – structure, replication, movement	
Week 12:	Lecture 23 – **2nd Internal examination**	
	Lecture 24 – Plant viruses – interaction with plants	
Week 13:	Lecture 25 – Viroids and sub-viral particles,	
	Lecture 26 – Bacteriophages, mycophages and cyanophages	
Week 14:	Lecture 27 – Breeding for virus resistance	
	Lecture 28 – Breeding for virus resistance,transgenic strategies	

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
3	Students will realize the heterogeneity and polyphyletc nature of the algae as a group, besides learning about the common features of its members. They will also be apprised of their diversity in form, structure and reproduction and the diverse habitats where algae abound. Besides, background information to understand and appreciate past and current systematic of algae will be provided.	Though illustrated and interactive lectures (power point presentations) and laboratory exercises to study diversity of algae through fresh and preserved specimens.	Students will be asked to note and highlight identifying features of the algae provided to them. Besides, they would be required to collect samples in their vicinity and to try to identify the same, realizing how pure or contaminated the water samples.
4	Students will become aware of the evolving systematic of algae and will become familiar with characteristic features of presently accepted different groups and interrelationships among	Though illustrated and interactive lectures (power point presentations) and laboratory exercises to study diversity of algae through fresh and preserved specimens.	Performance in the Laboratory exercises and interrogative discussions.

	these groups.		
5	Students will realize the vast economic, ecological and biotechnological project and realized potential which algae have, besides the contributions which these plants, as experimental systems have made in understanding the basic concepts of cell and molecular biology	Though illustrated and interactive lectures (power point presentations) and laboratory exercises involving extraction of economical important metabolites from some algae.	Performance in the Laboratory exercises and interrogative discussions.
Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Microbiology (bacteria)	Basic knowledge of microbiology	Lectures and practical demonstrations with microscopy	
Microbiology (bacteria)	Isolate and culture bacteria from nature, and to discern important microscopic characteristics of microbes	Through classroom teaching, demonstration and hands on training	Practical examination and group task to collect and identify various microbes
Microbiology (bacteria)	Learn and appreciate the importance of microbes	Through classroom teaching, demonstration	Class assignments and presentations
Microbiology	Learning about virus life cycle(s),adaptation to hosts, novel modes of infections, intra-celluar and genetic/genomic features	Lectures and practical demonstrations with microscopy of virus-host interactions; lytic/ lysogeny phases with T4/lambda phages	Class assignments and presentations on related topics; diagnosis of plant viruses
Viruses	Learning about interactions of viruses with hosts, field evolution of viruses and sustainability of virus disease management	Lectures and practical exercises on virus diseases in indicator plants/ hand-on diagnosis of infected plants using serological techniques	Class assignments and presentations on case studies of virus diseases; Identification of virus disease symptoms, and application of methods of virus detection

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1003

BIOLOGY OF BRYOPHYTES, PTERIDOPHYTES AND GYMNOSPERMS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 128 Hrs.**

Course Objectives:
The course aims to have understanding of evolutionary diversification of early land plants and morphological and reproductive inovations in land plants; bryophytes, pteridophytes and gymnosperms and to have understanding the process of evolution in a broad sense. Toe have a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants through Study of morphology, anatomy, reproduction and developmental changes.

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
4. **Information on the Ecological and Economic Importance of bryophytes , pteridophytes and gymnosperms will help to understand their role in ecosystem functioning.**
5. It will **create awareness on the threats to biodiversity and sensitize towards the Biodiversity Conservation for sustainable development.**

Contents:

Unit I: Comparative morphology and developmental anatomy of Anthocerophyta, Marchantiophyta and Bryophyta. (4 lectures); 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 Pteridophytes (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 developmental 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.

Teaching Plan:

Week 1: Lecture 1 – Comparative Morphology and develpmental anatomy of Anthocerophyta
Lecture 2 – Comparative Morphology and develpmental anatomy of Marchantiophyta
Week 2: Lecture 3 – Comparative Morphology and develpmental anatomy of Bryophyta
Lecture 4 – Vegetative and reproductive innovations
Week 3: Lecture 5 – Breeding system in bryophytes
Lecture 6 – Plant substratum relationship
Week 4: Lecture 7 – Growth Forms and life strategies.

Lecture 8 – Bryophytes as site indicators
Week 5 Lecture 9 – Role of Bryophytes in Ecosystem Dynamics and in global carbon budget
Lecture 10 – Bryogeography and conservation of bryophytes
Week 6:Lecture 11 – Meristem organization and organ diversity in Lycophytes
Lecture 12 – Review /discussion/ **first minor exam**
Week 7:Lecture 13 – Meristem organization and organ diversity in Ferns

Lecture 14 – Meristem organization and organ diversity in Ferns

Week 8:Lecture 15 – Comparative anatomy of vegetative and reproductive organs of Lycopods
Lecture 16 – Comparative anatomy of vegetative and reproductive organs of Ferns

Week 9:Lecture 17 – Fern Classification
Lecture 18 – Biogeography
Week 10:Lecture 19 - Diversity of Ferns - an ecological perspective
Lecture 20 – Gametophyte ecology of Ferns
Week 11:Lecture 21 – Nutrient ecology of Ferns
Lecture 22 –Review /discussion/**second minor exam**
Week 12:Lecture 23 –Taxonomy and distribution of Gymnosperms
Lecture 24 – Comparative Morphology and develpmental anatomy of conifers
Week 13:Lecture 25 – Comparative Morphology and develpmental anatomy of Gnetales
Lecture 26 – Reproductive Biology of Conifers
Week 14:Lecture 27 –, Reproductive Biology of Gnetales
Lecture 28 – Impact of coniferous forest on humal life

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	How the organ formation occur in the early land plants that resulted to species diversity of	Class room lectures and Practical demonstration, field visits	Hands on experiments, PPT, assignments, tests, field report

	bryophytesComparative morphology and developmental anatomy of Anthocerophyta, Marchantiophyta and Bryophyta. Vegetative and reproductive innovations, Breeding system in bryophytes		
2	Plant substratum relationship, Growth Forms and life strategies, Bryophytes as site indicators. Role of Bryophytes in Ecosystem Dynamics and in global carbon budget, Bryogeography and conservation	Class room lectures and Practical demonstration, field experimemts.	experiments, PPT, assignments, tests,
3	What are the reproductive strategies? Meristem organization and organ diversity in Pteridophytes, Comparative anatomy of vegetative and reproductive organs of Pteridophytes.	Class room lectures and Practical demonstration, field experimemts.	Lab exercises, PPT, assignments, tests,
4	Fern Classification, Biogeography, Diversity of Ferns - an ecological perspective, biogeography, Gametophyte development, Nutrient uptake	Class room lectures and Practical demonstration, field experimemts.herbarium and museum visits	Hands on experiments, PPT, assignments, tests, field report
5	Comparative morphology and developmental anatomy of Gymnosperms, Reproductive strategies of Gymnosperms, Impact of coniferous forest on human life	Class room lectures and Practical demonstration, field experimemts.herbarium and museum visits	Hands on experiments, PPT, assignments, tests, field report

MASTER OF SCIENCE IN BOTANY

Semester I

Course Code: BOT-Core-1004

PLANT SYSTEMATICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 128 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.

Teaching Plan*:

Week 1: Lecture 1 –Plant Systematics: concepts and components
Lecture 2 –Methods of Plant identification: Taxonomic keys, Floras and Monographs

Week 2: Lecture 3 –Classification of flowering plants: APG IV classification.
Lecture 4 –Basal angiosperms to superasterids- a braod outline

Week 3: Lecture 5 – Taxonomic hierarchy; Concept of taxa (family, genus, species)
Lecture 6– Species concept (taxonomic, biological, evolutionary).

Week 4: Lecture 7 – Taxonomic evidence: structural and biochemical characters
Lecture 8 – Palynology in relation to taxonomy

Week 5: Lecture 9 – Chromosome data in plant systematics
Lecture 10 – Phytochemical data in plant systematics

Week 6: Lecture 11 – Naming plants; scientific *vs* vernacular names, Binomial nomenclature
Lecture 12 – International Code of Nomenclature for Algae, Fungi and Plants (ICN): Principles and recommendations; **First minor exam**

Week 7: Lecture 13 – Typification, Nomenclatural types, Ranks, Author citation, Valid publications,
Lecture 14 – Priority of publications, Conservation of names, Name changes, Synonyms.

Week 8: Lecture 15 – Nomenclature Exercises
Lecture 16 – Molecular systematics: Concepts and methods

Week 9: Lecture 17 – Molecular markers in plant systematics
Lecture 18 – DNA sequence data, Types of sequence data, Sequence alignment,

Week 10: Lecture 19 - Phylogenetic analyses: parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining)
Lecture 20 – Role of phylogenomics in plant systematics

Week 11: Lecture 21 – DNA barcoding and its practical implications.
Lecture 22 – Botanic gardens of the world, **second minor exam**

Week 12: Lecture 23 – Herbaria of the world, , Functions of Herbarium,
Lecture 24 – Methods of collecting plants and documentation

Week 13: Lecture 25 – Herbarium specimens, Herbarium operations, Virtual herbarium;
Lecture 26 – Data Information Systems

Week 14: Lecture 27 – Statistics and morphometrics in plant systematics
Lecture 28 – Role of Botanical Gardens in conservation of biodiversity

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What do we mean by systematics.? What are different components of systematics? Why is systematics important? What are different data sources in systematics?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
2.	What are different methods of naming plants? What are different different principles of nomenclature? Why name changes?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
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??	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
4.	What are different methods of collecting and preserving plants? What is the importance of maintaining plants in botanic gardens?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2001

EVOLUTIONARY BIOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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.

Teaching Plan

Week 01	Unit I	Labs:Variation
Week 02	Unit I	Read Trees. MP to reconstruct trees. Introduce plant project and poster presentation.
Week 03	Unit I	Evolutionary trends Mesquite
Week 04	Unit II	Fossils
Week 05	Unit II	Biogeography Cucurbitaceae/other
Week 06	Unit III	Alleles in populations (fish simulation)
Week 07	Unit III	Poster presentation
Week 08	Unit III	Measuring fitness
Week 09	Unit III	PopGen
Week 10	Unit III	PopGen
Week 11	Unit IV	PopGen
Week 12	Unit V	Molecular evol (MEGA)
Week 13	Unit V	Phylogenetic inference (MEGA)
Week 14	Unit V	

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I-III	Understand patterns of biological variation and underlying processes responsible for these patterns.	Laboratory exercises on obervation and statistical analysis (descriptive; testing differences between populations). Plant project (4 weeks) culminating in poster presentation	Final practical examination. Poster presentation.
I, II, V	Understand evolutionary history and methods of study	Laboratory exercises, introduction to software for phylogenetic analysis of morphological and molecular data	Mid-term test; paper reading exercises (int. ass.); final examination
III, V	Understand processes of evolution and methods of study	Laboratory exercises including computer and physical simulations; read, summarize and discuss research paper	Mid-term test; paper reading exercises (int. ass.); final examination.
II, IV, V	Tree thinking (in contrast to group thinking), skills in application.	Laboratory exercises; reading exercises	Mid-term test; paper reading exercises (int. assess.); final examination
I, III, V	Population thinking (in contrast to typological thinking), skills in application.	Laboratory exercises; reading exercises	Mid-term test; paper reading exercises (int. ass.); final examination

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2002

DEVELOPMENTAL BIOLOGY OF PLANTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 meristematic 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, *in vitro* 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.

Week1	Unit 1
Week 2	Unit 1
Week3	Unit 2
Week4	Unit 2+3
Week5	Unit 3+ 4
Week6	Unit 4
Week7	Unit 4+5
Week8	Unit 5
Week 9	Unit 5
Week 10	Unit 5+6
Week11	Unit 6
Week12	Unit 7
Week 13	Unit 7+8
Week14	Unit 8

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
	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 meristematic 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?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
	Section B: Reproduction 5. How a shoot apical meristem transforms into an inflorescence and floral meristems and how these domains developmentally maintained? 6. How the male and female germ lines are established and how a variety of tissues coordinate to form gametes? 7. How seed development is accomplished and what are the	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

	mechanisms by which rejection reaction occurs during the progamic phase? 8. 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?		

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2003

RECOMBINANT DNA TECHNOLOGY AND PROTEOMICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 SOE-ing 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.

Teaching Plan*:

Week 1: Lecture 1 – Basics of protein structure (primary, secondary structure and folding)
Lecture 2 – Introduction to the concept of cloning
Week 2: Lecture 3 –Protein synthesis-Comparative account of translation in prokaryotes and eukaryotes
Lecture 4 – Commonly used enzymes in RDT
Week 3: Lecture 5 – Protein synthesis-Comparative account of translation in prokaryotes and eukaryotes
Lecture 6 – Tools and Methods used in cloning
Week 4: Lecture 7 – Post translational modifications
Lecture 8 – Introduction to plasmid vectors
Week 5: Lecture 9 –Over-expression of proteins in heterologous systems.
Lecture 10 – Plasmid vectors
Week 6: Lecture 11 – Over-expression of proteins in *E. Coli*- use of various kinds of vector

systems.
Lecture 12 –Other Vectors/ **first minor exam**

Week 7: Lecture 13 – Purification of proteins in *E. Coli*- using various kinds of vector systems and host
Lecture 14 – Other Vectors

Week 8: Lecture 15 – Protein Extraction and purification techniques – electrophoresis and column chromatography.
Lecture 16 – PCR and its applications

Week 9: Lecture 17 – Protein Extraction and purification techniques –ion exchange and affinity chromatography
Lecture 18 – PCR and its applications

Week 10: Lecture 19 - Introduction to proteomics, comparative account with genomics and transcriptomics.
Lecture 20 – Isolation of genes, construction of genomic and cDNA libraries

Week 11: Lecture 21 –Overview of various tools and techniques available in the field of proteomics and applications.
Lecture 22 – Screening of libraries for isolation of single genes

Week 12: Lecture 23 – Proteomics techniques
Lecture 24 – Methods for isolation of multiple genes

Week 13: Lecture 25 – Proteome analysis-two dimensional - separation of total cellular proteins isolation and sequence analysis of individual protein spots by mass spectroscopy.
Lecture 26 – Classical sequencing methods and introduction to NGS

Week 14: Lecture 27 – Applications of Proteomics.
Lecture 28 – Applications of RDT and Ethical Issues related to RDT

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the various tools and techniques available in the field of recombinant DNA technology and proteomics?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
2.	What are the various ethical issues involved with usage of recombinant DNA technology and proteomics?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
3.	What are the applications recombinant DNA technology and proteomics?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester II

Course Code: BOT-Core-2004

PATHOGENS AND PESTS OF CROP PLANTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 Hrs.**

Course Objectives:
This course aims to enhance understanding of students in basic concepts of mycology and importance of fungi, as well as 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

Teaching Plan*:

Week 1: Lecture 1 – Overview of Fungi and fungus-like organisms
Lecture 2 – A higher-level phylogenetic classification of the Fungi
Week 2: Lecture 3 – Reproduction (asexual and sexual), and mating compatibility.
Lecture4 – Chytridiomycota, Zygomycota, : Characteristics and important Genera
Week 3: Lecture 5 – Glomeromycota: Characteristics and important Genera
Lecture 6 – Ascomycota: Characteristics and important Genera
Week 4 Lecture 7 – Basidiomycota: Characteistics and important Genera
Lecture 8 – Importance and ecological role of fungi/ **first minor exam**
Week 5: Lecture 9 – Plant Pathology: General concepts
Lecture 10 –Herbivory and disease vectors: General concepts
Week 6: Lecture 11 – Agricultural pathogens and pests of national importance
Lecture 12 – Agricultural pathogens and pests of national importance
Week 7: Lecture 13 – Plant interactions with pathogens and pests – an overview
Lecture 14 – Plant interactions with pathogens and pests
Week 8: Lecture 15 – Plant interactions with pathogens and pests
Lecture 16 – Plant-virus interactions: Host range and transmission
Week 9: Lecture 17 – Plant-virus interactions: Pathogen derived resistance
Lecture 18 – Plant-fungus interactions
Week 10: Lecture 19 - Plant-fungus interactions
Lecture 20 – Plant-bacteria interactions
Week 11: Lecture 21 – Plant-Insect interactions : Chemical ecology
Lecture 22 – Plant-Insect interactions : Tritrophic interactions
Week 12: Lecture 23 – Plant-Insect interactions : Genetics and Genomics
Lecture 24 – Plant-Insect interactions/**Minor class project**
Week 13: Lecture 25 – Molecular approaches for investigation of plant diseases
Lecture 26 – Control mechanisms based on chemical treatments, biological control and genetic engineering
Week 14: Lecture 27 – Disease management strategies/**Journal club sessions****
Lecture 28 – Basic concepts in integrated disease/pest management and organic farming systems

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Basic knowledge of fungal biology		
2.	Isolate and culture fungi from nature, and to discern important microscopic characteristics of fungi	Through classroom teaching, demonstration and hands on training	Practical examination and group task to collect and identify fungi

3.	Identify diseases caused by viruses, bacteria, and fungiinfections; insect infestations	Demonstrate diseased specimens, and field visits. Hands-on training of various techniques to diagnose a plant disease	
4.	To apply knowledge on pests and pathogens in practicing sustainable agriculture	Journal club sessions** and multimedia support. Market surveys and field experiments to evaluate commercially available bio-control agents for plant health	Reverse learning exercises in topics viz. development of Bt resistant cotton in India and China
5.	To use knowledge on pathogen and pest diversity for engineering durable resistance in crop plants	Lec-dem classes, field collections of diseased and infested plant materials, diagnoses and assessment of genetic variability using biochemical assays and/or bioinformatic tools	Documentation of results in project report mode, self evaluation and class discussions

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: 128 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.

Teaching Plan*:

Week 1: Lecture 1 – Environment – the concepts and limits
Lecture 2 – Abiotic factors
Week 2: Lecture 3 – Biotic interactions
Lecture 4 – Biogeographical distributions and ecological equivalants
Week 3: Lecture 5 – Phytogeography
Lecture 6 – The biosphere, biomes and ecological zones
Week 4: Lecture 7 – Bioindicators and biomarkers
Lecture 8 – Environmental pollution and mitigation strategies
Week 5: Lecture 9 – Characteristics of population
Lecture 10 – Population dynamics and lifehistory patterns
Week 6: Lecture 11 – Age structure, fecundity and population growth
Lecture 12 – Competition and coexistence
Week 7: Lecture 13 – Population models – scramble and contest; prey-predator
Lecture 14 – Metapopulation dynamics/**first minor exam**
Week 8: Lecture 15 – Nature of ecosystem, production and energy flows
Lecture 16 – Water and nutrient cycling
Week 9: Lecture 17 – Resilience of ecosystem and management
Lecture 18 – Case studies of climax and disturbed ecosystems
Week 10: Lecture 19 – Concepts of ecosystem restoration and applications
Lecture 20 – Biodiversity – assessment, conservation and management
Week 11: Lecture 21 – Biodiversity – the acts and the conventions/**second minor exam**
Lecture 22 – Ecological factors and plant adaptation
Week 12: Lecture 23 – Sustainable development
Lecture 24 – Natural resource management in changing environment
Week 13: Lecture 25 – Molecular ecology and application in conservation biology
Lecture 26 – Global climatic patterns and variation over time
Week 14: Lecture 27 – Coping with environmental variation
Lecture 28 – Environmental impacts and their assessment

***A 6 hour lab exercises per week for hands on practical exercises on the subject**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the limiting factors controlling distribution and growth of organisms?	Single and multiple factor based growth assessment of model organisms	Internal assessment, mid-term test and final examination
2.	What are the characteristics of organisms as population, community and	Demographic analysis; phytosociological analysis; Association analysis	Internal assessment, mid-term test and final examination Internal assessment,

	ecosystems?		mid-term test and final examination
3.	What are the intra- and inter-specific interactions?	Mutualistic and antagonistic relationship between species	Internal assessment, mid-term test and final examination
4.	What are the ecosystem functions?	Assessment of provisioning and regulating services of model ecosystems	Internal assessment, mid-term test and final examination
5.	What are applications of ecological knowledge for the benefit of anthropogenic society?	Case studies of restoration of degraded ecosystems and conservation of species and ecosystems	Internal assessment, mid-term test and final examination

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: 128 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.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants, John Wiley and Sons Ltd., UK.
3. Butenko, R.G. (2000). Plant Cell Culture, University Press of Pacific.
4. Davies, P.J. (2010). 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. Kirakosyan, A. and Kaufman, P.B. (2016). Recent Advances in Plant Biotechnology, Springer, UK.
7. Kochhar, S.L. (2016). Economic Botany: A comprehensive study, Fifth edition, Cambridge University Press, NY.
8. Primrose, S.B. and Twyman, R.M. (2016). Principles of Gene Manipulation, 8th edition, John Wiley and Sons Ltd., Chicester, UK.
9. Ricroch, A., Chopra, S. and Fleischer, S.J. (2014). Plant Biotechnology: Experiences and future prospects, Springer International Publishing AG, Springer, Switzerland.
10. Wickens, G.E. (2004). Economic Botany: Principles and Practices, Springer, ISBN 978-0- 7923-6781-9.
11. Research articles and review articles related to the course contents provided by faculty during the course.

Teaching Plan*:

Week 1:	Lecture 1 –	General Introduction and application of Plant biotechnology to industries and agriculture; brief history of plant tissue culture, Concept of totipotency.
	Lecture 2 –	In vitro morphogenesis; different pathways of in vitro regeneration (organogenesis and somatic embryogenesis), illustration of direct and indirect organogenesis
Week 2:	Lecture 3 –	Impact of growth regulators and physico-chemical factors on differentiation. cytodifferentiation; molecular basis of differentiation.
	Lecture 4 –	Direct and indirect somatic embryogenesis. Molecular and biochemical aspects of somatic embryogenesis
Week 3:	Lecture 5 –	Embryo rescue technique, synthetic seeds
	Lecture 6 –	Meristem culture and production of virus-free plants
Week 4:	Lecture 7–	Protoplast isolation, culture and regeneration; somatic hybridization and its significance in crop improvement.
	Lecture 8 –	Induction of androgenesis and gynogenesis and production of haploids
Week 5:	Lecture 9 –	In vitro conservation, cryopreservation
	Lecture 10 –	Principles and methods of genetic transformation, different types of vectors, marker and reporter genes
Week 6:	Lecture 11 –	Direct methods of gene transfer (particle bombardment, electroporation, microinjection, PEG-mediated, etc.)
	Lecture 12 –	Indirect method of gene transfer, floral-dip transformation, expression analysis of transgenic tissues.
Week 7:	Lecture 13 –	General introduction of medicinal plants and their human values, plant–based bioactive compounds (secondary compounds) e.g. terpenoids, flavonoids, and alkaloids, techniques for their extraction, isolation and characterization.
	Lecture 14 –	**First minor exam**
Week 8:	Lecture 15 –	*Agrobacterium* biology and biotechnology

Lecture 16 – Components of a binary vector system

Week 9: Lecture 17 – Factors influencing transgene expression levels; transgene silencing

Lecture 18 – Genetic and molecular analysis of transgenic plants

Week 10: Lecture 19 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Lecture 20 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Week 11: Lecture 21 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Lecture 22 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Week 12: Lecture 23 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Lecture 24 – Case studies of plant improvement using transgenic technology (combined with selected topics of Unit IV)

Week 13: Lecture 25 – Marker-free transgenics; chloroplast transformation

Lecture 26 – **Second minor exam**

Week 14: Lecture 27 – Genome editing for crop improvement

Lecture 28 – Environmental, social and legal issues related to use of transgenic plants

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the principles and methods associated with in vitro regeneration and propagation of plants?	In vitro conservation of rare, endangered and recalcitrant plant species. Multiplication of commercially important taxa employing somatic embryogenesis, organogenesis, embryo rescue, synthetic seeds. Somatic hybridization to resolve incompatibility and improvement of taxa.	Internal assessment, mid-term test and final examination
2.	What are the methods/approaches used for development and analysis of transgenic plants?	Principles and methods used for phenotypic, genetic and molecular analysis of transgenic plants.	Internal assessment, mid-term test and final examination
3.	What are the applications	Detailed case studies on use of	Internal assessment,

	of transgenic technology in plant science?	transgenic technology for basic and applied research in plants	mid-term test and final examination
4.	What are the parameters that are important for effective design and use of transgenic technology?	Study of factors governing transgene expression levels, transgene silencing, environmental impacts and assessment.	Internal assessment, mid-term test and final examination
5.	What are the current research paradigms in economically important plants?	Case study – based analysis	Internal assessment, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Core-3003

GENETICS AND CYTOGENETICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 organization 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.

Teaching Plan:

Week1	Unit 1
Week 2	Unit 1 + 2
Week3	Unit 2
Week4	Unit 2 + 3
Week5	Unit 3
Week6	Unit 3 +4
Week7	Unit 4
Week8	Unit 5
Week 9	Unit 5
Week 10	Unit 6
Week11	Unit 6
Week12	Unit 7

Week 13	Unit 7
Week14	Unit 8

Facilitating the achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
1. **Unit 1:**	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.	Theory lectures and laboratory based exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
2. **Unit 2:**	The unit will enable the students to learn about - mapping genes in bacteria - functional allelism - gene regulation in prokaryotes: the components and the mechanisms.	Theory lectures, numerical and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
3. **Unit 3:**	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
4. **Unit 4:**	The unit will provide an	Theory lectures	Tutorials/ assignments, seminars

	understanding of - the different levels at which gene regulation occurs in a eukaryotic cell. - the various components and mechanisms involved.	and hands-on relevant laboratory exercises, tutorials	and tests. Theory and Practical examinations.
5. **Unit 5:**	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
6. **Unit 6:**	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
7. **Unit 7:**	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
8**. Unit 8:**	The unit will provide an understanding of - the basic concepts of epigenetics, the underlying	Theory lectures and hands-on relevant laboratory	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.

	mechanism and inheritance of the epigenetic modifications. - the tools to study epigenetics..	exercises, tutorials	

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Core-3004

CELL AND MOLECULAR BIOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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, organization, 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 analyze 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 processes of 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 modifications in 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.

Teaching Plan*:

Week 1: Lectures 1, 2 – Infective particles: prions, viroids, cell theory vs. cell body concept, multicellularity vs. supracellularity

Week 2: Lecture 3 – Cell Wall: temporal and spatial dynamism in structure, structural and functional roles, in planta and ex planta uses, cell wall biotechnology

Lecture 4 – Biological membranes: from PLP model to Dynamically Structured Mosaic Model

Week 3: Lectures 5, 6 – Nucleus: its components; Nuclear envelope with emphasis on structure and biogenesis of pore complex; Transport and trafficking.

Week 4: Lectures 7 – Condensation and packaging of DNA in eukaryotic and prokaryotic chromosome

Lecture 8 - State of chromatin during transcription and replication, role in gene regulation

Week 5: Lecture 9, 10 - Cell multiplication and turnover: Cell division, cell cycle controls, breakdown of cell cycle control, programmed cell death

Week 6: Lecture 11 – Introduction to various tools used to study the plant cytoskeleton, Components and assembly of the plant cytoskeleton, cytoskeleton accessory proteins, important contrasts with the animal cytoskeleton

Lecture 12 – Use of genetic, biochemical and molecular tools to study the cytoskeleton and related processes in model plant systems, evolution of gene families encoding the plant cytoskeleton / **minor project assignment**

Week 7: Lecture 13 – Components of plant and animal endo-membrane systems, vesicular trafficking

Lecture 14 – Trans-membrane proteins, basic concepts in protein sorting and maturation in plant cells

Week 8: Lecture 15 –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

Lecture 16 –Nuclear genome: Gene and Promoter structure- Variation in size and distribution of introns and exons and function; promoter diversity and function; other Cis regulatory elements

Week 9: Lecture 17 –Organellar genome: Structure, organisation, diversity and evolution of mitochondrial and chloroplast genomes

Lecture 18 –Organellar genome: Cross-talk between nuclear and organellar genetic machinery and its implications: Applications of organellar genomics

Week 10: Lecture 19 - Computational tools: Sequence and structural features of genomic components

Lecture 20 –Computational tools: Principles and tools of sequencecomparison

Week 11: Lecture 21 – Computational tools: Principles and tools of sequencecomparison

Lecture 22 –DNA replication: Replicative machinery of nuclear and organellar genomes/ **second minor exam**

Week 12: Lecture 23 – DNA replication: Replicative processesof nuclear and organellar genomes including structural insights, proof reading, fidelity

Lecture 24 – Transcriptional process in nuclear and organelle genomes: Trans factors, mediator complexes;

Week 13: Lecture 25 –Transcriptional process in nuclear and organelle genomes: Co-transcriptional and Post-transcriptional processes-Initiation, elongation, termination,

Lecture 26 – Transcriptional process in nuclear and organelle genomes:

polyadenylation, splicing, alternative splicing

Week 14: Lecture 27 – Translation and post-translational modifications in nuclear and organellar genome: Pioneering round of translation; translation and PTMs
Lecture 28 – Small RNA in gene regulation

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. (Lecture 1 & 2)	Awareness about the discovery, structure, mode of multiplication and evolution of the naked infective particles which cause plant/animal diseases. Paradigm shift from cell theory to cell body concept and multicellularity to supracellularity.	Through class room lectures and projections. Lectures and study of structures in plants projected to support the concepts.	To study amino acid/nucleotide sequence variation among viroids and strain of prions by *in silico* method.
2. (1 Lecture)	Change in concept from cell walls being considered as inanimate rigid box to spatially and temporally dynamic structure. Awareness about the targets of cell wall biotechnology.	Lectures and laboratory exercise to study the differences between Type and Type II cell walls	To summarize the targets and achievement of cell wall biotechnology.
3. (1 Lecture)	Historical developments about membrane biology leading to the current concept of membranes as dynamically mosaic structures.	Lectures followed by an experiment to demonstrate basic tenets of membranes.	Understanding and interpretation of recent research paper on membranes structure and functions
4	What are the unique characteristics and essential roles of the plant cytoskeleton?	Interactive demonstration of polymerization and assembly of the cytoskeleton, discussion on classic citations, Minor project on molecular evolution of cytoskeleton gene families in plants	Practical skills relating to independent data generation/retrieval; framing hypotheses examining concepts related to the plant cytoskeleton
5	How do newly synthesized proteins reach their intended destinations within the cell and mature?	Multimedia support for concepts taught, use of P-SORT and other tools to predict protein sorting signals, discussion on emerging hypotheses in new citations on protein trafficking	Comprehension skills tested by MCQs and assignment related to membrane proteins and role of motifs during protein maturation
6	Understanding the nucleus the command unit of the cell, its components, especially nuclear envelope, its role in controlling the inflow and outflow of information, open mitosis, gene regulation, etc. and chromatin, its condensation, states during replication and transcription, condensation and	Through lectures and projections, photographs, simulations, etc.	Examples of epigenetic changes affecting plants and animals.

	histone modification as inheritable epigenetic characters.		
7	Becoming aware of cell cycle controls and consequences of their breakdown. Programmed cell death as a defense and developmental regulatory mechanisms.	Through lectures, projections and animations. Study of nuclear fragmentation DNA laddering consequent to induced apoptosis.	
8	What are the various features of the eukaryotic genome and gene structures?	Comparative analysis across multiple genomes, and genes	Practical exercise to understand genome structure
9	What are the various computational tools to analyse gene and genome structure, and their underlying principles	Assignments based on specific examples of gene and promoters, and components of replication and transcription	Minor project based on *in-silico* exercise
10	What are the various components and processes in DNA replication, what are the similarities and how do these differ among nuclear and organellar genomes?	Assignment using specific case studies using components of replication	Assessment based on understanding recent findings in DNA replication.
11	What are the similarities and differences intranscriptional process in nuclear and organelle genome?	Comparative analysis based on available literature, including research articles on transcriptional processes	Assessment based on analysis of recent research findings.
12	How is the genomic information converted from RNA to protein? How does the cellular machinery maintain fidelity in translation? What are the translation and post-translational modificationsin nuclear and organellar genomes?	Analysis of structural features and understanding the basis of difference	Comparative analysis based on available literature, including research articles.
13	Small RNA and gene regulation	Understanding the basis of gene regulation	Assignment based on specific case studies from literature

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4001

CELL AND DEVELOPMENTAL BIOLOGY (ELECTIVE COURSE)

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 tumors; 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 organization; 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

Teaching Plan*:

Week 1: Lecture 1 – Positional information and Cell fate;
Lecture 2 – morphogenetic gradient; polarity determination; commitment, differentiation

Week 2: Lecture 3 – Genetic and environmental regulation of basic development processes
Lecture 4 – Hormonal regulation of basic development processes

Week 3: Lecture 5 – Hormonal regulation of basic development processes
Lecture 6 – Cross talk between various growth regulators

Week 4: Lecture 7 – Cross talk between various growth regulators
Lecture 8 – Cell cycle regulation

Week 5: Lecture 9 – Cell cycle regulation
Lecture 10 – Cancer v/s plant tumours

Week 6: Lecture 11 – Differentiation, programmed cell death and senescence
Lecture 12- Cytoskeleton and signal transduction

Week 7: Lecture 13- Vegetative development-. Comparative account of organization of shoot and root apical meristems. / First **minor exam**
Lecture 14 – Regulation of meristem size

Week 8: Lecture 15 –Lateral organ initiation from root and shoot meristems
Lecture 16 – Lateral organ initiation from root and shoot meristems

Week 9: Lecture 17- Regulation of reproductive development: Transition from vegetative to reproductive phase
Lecture 18: Molecular basis of flower development and its regulation

Week 10: Lecture 19: Molecular basis of flower development and its regulation
Lecture 20: Fruit and seed development

Week 11: Lecture 21-Chromatin organisation: Small RNA as regulatory molecule
Lecture 22 – Epigenetic-Role of histones and small RNA in chromatin organization
Week 12: Lecture 23 – RdDM; paramutations, genomic imprinting; gene dosage;
Lecture 24– RdDM; paramutations, genomic imprinting; gene dosage
Week 13: Lecture 25 – Chromatin remodeling factors, models and processes
Lecture 26- Chromatin state during replication and transcription; inheritance of epigenetics
Week 14: Lecture 27 – Epigenetic regulation of developmental processes
Lecture 28 – Epigenetic regulation of developmental processes

***A 6 hour lab exercises per week for hands on practical exercises on the subject**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the various basic cellular events and processes such as positional information, cell fate, morphogenetic gradient, cell polarity, and various factors (Genetic, environmental, and hormonal) that regulate basic development processes?	Teaching and learning activity involving lectures, supported by research articles, and laboratory exercise	Assignment based on literature survey, research articles and classroom presentation by students
2.	How do regulation of development occur and what are the underlying factors? with special reference to understanding of signal transduction, differentiation, cycle regulation, Programmed cell death and senescence	Teaching and learning based on lectures, ICT based demonstration of concepts, supported by research articles, and laboratory exercise	Assignment and analysis based on available literature, including research articles
3.	What are the various molecular players in development of vegetative organs? How do the various molecular elements interact and influence development?	Teaching activity will involve lectures, supported by research articles; ICT based demonstration of developmental models, analysis of mutants; laboratory exercises	Teaching assignment based on case studies from literature
4.	What are the various molecular	Teaching activity will	Assignment based on

	players in development of reproductive organs, fruit and seed? How do the various molecular elements interact and influence development?	involve lectures, supported by research articles; ICT based demonstration of developmental models, analysis of mutants; laboratory exercises	specific case studies from literature and presentation
5.	What are the major regulators of chromatin organization and remodeling? What role does small RNA and histones play? How does chromatin remodeling and epigenetics regulate developmental and adaptive process?	Teaching activity will involve lectures, supported by research articles; In-silico analysis of small RNA; laboratory exercises	Assignment and analysis based on available literature, including research articles

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4002

MICROBIAL TECHNOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 128 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.

Teaching Plan*:

Week 1: Lecture 1 – Introduction and diversity of the microbial world
Lecture 2 – Microbial nutrition, growth and metabolism

Week 2: Lecture 3 – Microbial nutrition, growth and metabolism
Lecture 4 – Agriculturally important microorganisms; Biological nitrogen fixation
Week 3: Lecture 5 – Types of Mycorrhizae; role of arbuscular mycorrhiza in sustainable agriculture
Lecture 6 – Biocontrol; role of fungi, bacteria and virues in control of pathogens and pests (Microbial pesticides)
Week 4: Lecture 7 – Characteristics of PGPR and applications
Lecture 8 – Distribution and implications of microbes in air, water, and soil
Week 5: Lecture 9 – Microbes in drinking water and domestic waste treatment systems
Lecture 10 – Microbial degradation of pesticides and toxic chemicals-mechanisms
Week 6: Lecture 11 – Biodegradation of the agricultural residues, bioremediation of contaminated soils
Lecture 12 – Microbes in nanotechnology / **first minor exam**
Week 7: Lecture 13 – Microbes in/ as biosensors
Lecture 14 – Microbes in extreme environments (pH, temperature)
Week 8: Lecture 15 – Microbes in extreme environments (temperature, pressure)
Lecture 16 – Microbes in extreme environments- applications
Week 9: Lecture 17 – Fermentation, fermented foods
Lecture 18 – Fermenter designs
Week 10: Lecture 19 - food spoilage, methods of food preservation
Lecture 20 – Microbes in recovery of metal (bioleaching)
Week 11: Lecture 21 – Microbial enhanced recovery of oil (MEOR)
Lecture 22 – Cell and enzyme immobilization /**second minor exam**
Week 12: Lecture 23 – microbial enzymes of industrial interest – Paper industry
Lecture 24 – microbial enzymes of industrial interest – Detergent industry
Week 13: Lecture 25 – microbial enzymes of industrial interest – Textile industry
Lecture 26 – microbial enzymes of industrial interest – leather industry
Week 14: Lecture 27 – Novel medicines from microbes
Lecture 28 – Novel medicines from microbes

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understand and appreciate role of microbes in their life?	Study of role of microbes in food, medicine, technology, environment and agriculture	
2.	Environmentally more sensitive citizens; advantages of using microbes over conventional methods involving chemicals.	Interactive seminars, discussions and site visits and research institutes on microbiology	Internal assessment and seminars on the topics
3	Develop theoretical and	Hands on training of basic	Practical examination

	technical skills to handle microbes.	techniques of microbiology	
4.	Scientific basis of application of microbes	study of mechanisms and demonstration techniques to isolate industrially important microbes from various ecosystems	Written examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4003

GENETICS, GENOMICS AND MOLECULAR BREEDING

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 128 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.

Teaching Plan:

Week1	Unit 1
Week 2	Unit 1
Week3	Unit 2
Week4	Unit 2+3
Week5	Unit 3+ 4
Week6	Unit 4
Week7	Unit 4+5
Week8	Unit 5
Week 9	Unit 5
Week 10	Unit 5+6
Week11	Unit 6
Week12	Unit 7
Week 13	Unit 7+8
Week14	Unit 8

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Unit1	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.	Theory lectures and laboratory based exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
Unit 2	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,,	Theory lectures, hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
Unit 3	The unit will provide an understanding of -the different theories that have been proposed to explain heterosis. - different ways of exploiting heterosis..	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
Unit 4	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
Unit 5	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
Unit 6	The students will learn -how to associate molecular markers	Theory lectures and hands-on relevant	Tutorials/ assignments, seminars

	with the trait of interest. - how to integrate molecular methods with conventional improvement strategies to accelerate plant breeding.	laboratory exercises, tutorials	and tests. Theory and Practical examinations.
Unit 7	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.
. **Unit8** .	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.	Theory lectures and hands-on relevant laboratory exercises, tutorials	Tutorials/ assignments, seminars and tests. Theory and Practical examinations.

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4004

BIOINFORMATICS, COMPUTATIONAL BIOLOGY AND BIOSTATISTICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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

- This section would be common between students of the paper "Genomics and Proteomics" and this paper.

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.

Teaching Plan**:

Week 1: Lecture 1 – Databases and online tools
Lecture 2 – Databases and online tools
Week 2: Lecture 3 – Databases and online tools
Lecture 4 – Databases and online tools
Week 3: Lecture 5 – Fundamentals of computer programming and algorithm development
Lecture 6 – Fundamentals of computer programming and algorithm development
Week 4: Lecture 7 – Fundamentals of computer programming and algorithm development
Lecture 8 – Fundamentals of computer programming and algorithm development
Week 5: Lecture 9 – Programming in PERL – Theory and Practicals
Lecture 10 – Programming in PERL – Theory and Practicals
Week 6: Lecture 11 – Programming in PERL – Theory and Practicals
Lecture 12 – Programming in PERL – Theory and Practicals
Week 7: Lecture 13 – Programming in PERL – Theory and Practicals
Lecture 14 – Programming in PERL – Theory and Practicals
Week 8: Lecture 15 – **First minor exam**
Lecture 16 – Programming in PERL – Theory and Practicals
Week 9: Lecture 17 – Programming in PERL – Theory and Practicals
Lecture 18 – Programming in PERL – Theory and Practicals
Week 10: Lecture 19 – Programming in PERL – Theory and Practicals
Lecture 20 – Programming in PERL – Theory and Practicals
Week 11: Lecture 21 – Programming in PERL – Theory and Practicals
Lecture 22 – Biostatistics – Basics to Advanced – Theory and Practicals
Week 12: Lecture 23 – Biostatistics – Statistical tools and application – Theory and Practicals
Lecture 24 – Introduction to NGS data analysis
Week 13: Lecture 25 – Introduction to NGS data analysis
Lecture 26 – **Second minor exam**
Week 14: Lecture 27 – Introduction to *in silico* drug design and molecular modeling
Lecture 28 – Introduction to *in silico* drug design and molecular modeling

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks

No.			
1.	What are the common databases and online tools that are useful for plant scientists? How do we gain expertise in their use?	Based largely on practical exercises performed by students; students will be trained to develop familiarity in the use of databases and online tools using online resources.	Internal assessment, mid-term test and final examination
2.	How do we apply logical reasoning in development of algorithms for analysis of biological data?	Students will be trained in basic concepts in algorithm development that would be required for writing programs.	Internal assessment, mid-term test and final examination
3.	Development of programs using PERL for analysis of biological data	Based largely on practical exercises on analysis of biological data using various concepts in PERL	Internal assessment, mid-term test and final examination
4.	Fundamental understanding of NGS techniques and analysis of NGS data	Introduction to concepts and fundamental processes associated with NGS data generation and analysis	Internal assessment, mid-term test and final examination
5.	Basic principles of *in silico* drug design and molecular modelling	Introductory lectures on the topic and basic exercises using online resources	Internal assessment, mid-term test and final examination
6.	Fundamental understanding of Biostatistics – concepts and applications.	Students would learn from basic to advance biostatistics. The subject would emphasize on understanding, analyzing and interpretation of biological data. Focus would be on providing hands on training on various statistical tools.	Internal assessment, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT- Elective - 4005

ALGAE, ENVIRONMENT AND HUMAN WELFARE

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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-relationship, 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:

1. egyankosh.ac.in/bitstream/123456789/16683/1/Unit-7.pdf
2. Carmichael, W.W. (ed.) (2013). The Water Environment: Algal Toxins and Health. Plenum Press, NY. ISBN 13: 978-1-4613-3269-5. 490pp.

Teaching Plan*:

Week 1: Lecture 1 – Photosynthesis advancement in various class of algae
Lecture 2 – Photosynthesis advancement in various class of algae
Week 2: Lecture 3 – Photosynthesis advancement in various class of algae
Lecture 4 – Photosynthesis advancement in various class of algae
Week 3: Lecture 5 – Nitrogen fixation and assimilation in algae
Lecture 6 – Nitrogen fixation and assimilation in algae
Week 4: Lecture 7 – Nitrogen fixation and assimilation in algae
Lecture 8 – Nitrogen fixation and assimilation in algae
Week 5: Lecture 9 – Nitrogen fixation and assimilation in algae
Lecture 10 – Tolerance and detoxification mechanisms of HMs in algae
Week 6: Lecture 11 – Tolerance and detoxification mechanisms of HMs in algae
Lecture 12 – Tolerance and detoxification mechanisms of HMs in algae
Week 7: Lecture 13 – Tolerance and detoxification mechanisms of HMs in algae
Lecture 14 – Tolerance and detoxification mechanisms of HMs in algae
Week 8: Lecture 1 – Algal application for human welfare
Lecture 2 – Algal application for human welfare
Week 9: Lecture 3 – Algal application for human welfare
Lecture 4 – Algal application for human welfare
Week 10: Lecture 5 – Algal Lipids, biodiesel and biofuel production
Lecture 6 – Algal Lipids, biodiesel and biofuel production
Week 11: Lecture 7 – Algal Lipids, biodiesel and biofuel production
Lecture 8 – Algal Lipids, biodiesel and biofuel production
Week 12: Lecture 9 – Algal Lipids, biodiesel and biofuel production
Lecture 10 – Algal Lipids, biodiesel and biofuel production
Week 13: Lecture 11 – Algal Lipids, biodiesel and biofuel production
Lecture 12 – Biotechnological advancements in algal research
Week 14: Lecture 13 – Biotechnological advancements in algal research
Lecture 14 – Biotechnological advancements in algal research

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	The student will learn about organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

	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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4006

GENOMICS AND PROTEOMICS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**)** **Duration: 128 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

Teaching Plan*:

Week 1	Lecture 1	Introduction to Proteomics and its types.
	Lecture 2	Tools and techniques (IEF, 2D-PAGE) for proteome analysis.
Week 2	Lecture 3	Introduction to Mass spectrometry
	Lecture 4	Databases and software's for proteomics
Week 3	Lecture 5	Protein identification by Peptide Mass Fingerprinting
	Lecture 6	Protein identification/Sequencing by tandem MS
Week 4	Lecture 7	**Internal Assessment I (presentations by students)**
	Lecture 8	**Internal Assessment I (presentations by students)**
Week 5	Lecture 9	Proteome analysis by Labeled gel free methods
	Lecture 10	Proteome analysis by Label free gel free methods
Week 6	Lecture 11	Comparative proteomics, interactomics
	Lecture 12	Protein chips and arrays
Week 7	Lecture 13	Proteogenomics
	Lecture 14	Applications of proteome analysis in agriculture, forensic and medical sciences.
Week 8	Lecture 15	Genome sequencing methods and strategies used for sequencing genomes.
	Lecture 16	Next Generation Sequencing Technologies.
Week 9	Lecture 17	Next Generation Sequencing Technologies.
	Lecture 18	Next Generation Sequencing Technologies
Week 10	Lecture 19	Methods for sequence alignment and genome annotation.
	Lecture 20	Methods to study gene expression and understanding the concept of relative gene expression
Week 11	Lecture 21	Methods to study gene expression and understanding the concept of relative gene expression
	Lecture 22	Creating knock out and knock down mutants. Resources of mutants available for functional genomics. Gene tagging, gene and promoter trapping, knockout and knock-down mutants.
Week 12	Lecture 23	**Internal Assessment II**
	Lecture 24	Dynamic modulation of protein structure and function

Week 13	Lecture 25	Introduction to comparative genomics of model plants and related crop species.
	Lecture 26	Genome imprinting
Week 14	Lecture 27	Introduction to RNAi and gene silencing. 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
	Lecture 28	Introduction to RNAi and gene silencing. 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

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
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. Principle of analysing genome wide gene expression and its utility.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
2	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. Comparative genomics and its utility in deciphering genome organization of a sequenced genome.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
3	Control of gene expression at transcriptional and post transcriptional levels by genome imprinting and formation of heterochromatin by small RNAs. Understand and explain current scenario of plant proteomics including what is proteomics? It's different types, need and limitations.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
4	Understand methods/procedures and different tools and techniques applied for proteome analysis. Plan and execute a proteome analysis experiment	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
5	Understand application of proteome analysis in plant sciences in particular and in daily life in general.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4007

TOPICS IN PLANT PHYSIOLOGY AND BIOCHEMISTRY

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 defense 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 defense 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 defense mechanisms; induced phytochemical responses; biochemical mechanisms of allelopathy.

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 climacteric 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-defense, 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

Teaching Plan*:

Week 1: Lecture 1 – Stress Physiology
Lecture 2 – Stress Physiology
Week 2: Lecture 3 – Stress Physiology
Lecture 4 – Stress Physiology
Week 3: Lecture 5 – Oxidative and nitrosative stress and antioxidative strategies
Lecture 6 – Oxidative and nitrosative stress and antioxidative strategies
Week 4: Lecture 7 – Oxidative and nitrosative stress and antioxidative strategies
Lecture 8 – Oxidative and nitrosative stress and antioxidative strategies
Week 5: Lecture 9 – Secondary metabolites and chemical defence
Lecture 10 – Secondary metabolites and chemical defence
Week 6: Lecture 11 – Secondary metabolites and chemical defence
Lecture 12 – Secondary metabolites and chemical defence
Week 7: Lecture 13 – Physiology of seed development
Lecture 14 – Physiology of seed development
Week 8: Lecture 15 – Physiology of seed development
Lecture 16 – Physiology of seed development
Week 9: Lecture 17 – Fruit development and ripening
Lecture 18 – Fruit development and ripening
Week 10: Lecture 19 - Fruit development and ripening
Lecture 20 – Fruit development and ripening/**Internal examination**

Week 11: Lecture 21 – Programmed cell death (PCD)
Lecture 22 – Programmed cell death (PCD)
Week 12: Lecture 23 – Programmed cell death (PCD)
Lecture 24 – Programmed cell death (PCD)
Week 13: Lecture 25 – Sensory physiology
Lecture 26 – Sensory physiology
Week 14: Lecture 27 – Sensory physiology
Lecture 28 – Sensory physiology

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
3.	Various secondary metabolites from plants and their roles for plant defense as well as human welfare	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
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. Fruit development and ripening is an important aspect of plant development, understanding of this process can help in	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

	preventing post harvest losses. Student would acquire a detailed understanding of major regulatory (biochemical/molecular) framework for the process.		
5.	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. 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.	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

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MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4008

LANDSCAPE ECOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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.

Teaching Plan*:

Week 1: Lecture 1 – Landscapes: the definition and typology
Lecture 2 – Landscapes: classification and nomenclature

Week 2:	Lecture 3 – Landscape design and management system
	Lecture 4 – Landscape design and management system case studies
Week 3:	Lecture 5 – Patterns and processes
	Lecture 6 – Scale and context in landscape
Week 4:	Lecture 7 – The abiotic template
	Lecture 8 – The abiotic template
Week 5:	Lecture 9 – The biotic template
	Lecture 10 – The biotic template
Week 6:	Lecture 11 – Disturbance – meaning and measurement
	Lecture 12 – Disturbance – meaning and measurement/ **first minor exam**
Week 7:	Lecture 13 – Disturbance – the implications
	Lecture 14 – Landscape dynamics
Week 8:	Lecture 15 – Equilibrium and non-equilibrium landscapes
	Lecture 16 – Anthropogenic influences
Week 9:	Lecture 17 – Management influences
	Lecture 18 – Landscape models – disturbance-succession models
Week 10:	Lecture 19 - Landscape models – disturbance-succession models
	Lecture 20 – Natural range of variability
Week 11:	Lecture 21 – Pattern and process in landscape ecology
	Lecture 22 – Pattern and process in landscape ecology/**second minor exam**
Week 12:	Lecture 23 – Population and community dynamics
	Lecture 24 – Population and community dynamics
Week 13:	Lecture 25 – Landscape genetics
	Lecture 26 – Conservation landscapes – national and international scene
Week 14:	Lecture 27 – Conservation landscapes – diversity
	Lecture 28 – Conservation landscapes – management

***A 6 hour lab exercises per week for hands on practical exercises on the subject**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Why and how the diverse landscapes occur in nature and how they are managed by human society?	Study of landscape photographs and field visits to natural and cultural landscapes.	Internal assessment, assignments, mid-term test and final examination
2.	What is the implication of spatial and temporal changes occurring in	Assessment of Carbon stocks in spatial and temporal scales and deriving the net carbon storage in a	Internal assessment, assignments, mid-term test and final

	landscapes?	landscape	examination
3.	How to monitor the changes occurring in the landscapes?	Application of RS & GIS techniques to derive landscape change matrix and indices.	Internal assessment, assignments, mid-term test and final examination
4.	What are the applications of landscape management and landscape ecology?	Case study based assignments	Internal assessment, assignments, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4009

AGRICULTURAL ECOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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.

Teaching Plan*:

Week 1: Lecture 1 – Agroecology – definitions, scope, approaches and viewpoints
Lecture 2 – Domestication, selection and protection of agrodiversity

Week 2: Lecture 3 – Domestication, selection and protection of agrodiversity
Lecture 4 – Crop wild relatives
Week 3: Lecture 5 – Ecological experimentation in agroecology
Lecture 6 – Ecosystem functioning and farming systems
Week 4: Lecture 7 – Energy and material flows
Lecture 8 – Trophic relations
Week 5: Lecture 9 - Spatial scales and ecological footprints
Lecture 10 - Organic farming
Week 6: Lecture 11 – GMOs and their implications in farming systems
Lecture 12 – Climate change – impacts on agriculture and adaptation mechanisms/**first minor exam**
Week 7: Lecture 13 – Ecological problems of crop cultivation and solutions – pollution
Lecture 14 – Ecological problems of crop cultivation and solutions – leakage and erosion
Week 8: Lecture 15 – Land development
Lecture 16 - Diseases
Week 9: Lecture 17 – Weeds and pests
Lecture 18 – Weeds and pests
Week 10: Lecture 19 – Chemicals
Lecture 20 – Biological and ecological control
Week 11: Lecture 21 - Biological and ecological control
Lecture 22 – Interactions between wild and domesticated diversity
Week 12: Lecture 23 – Interactions between wild and domesticated diversity
Lecture 24 – Landscape fragmentation/**second minor exam**
Week 13: Lecture 25 – relationships and interdependencies of biodiversity
Lecture 26 – relationships and interdependencies of biodiversity
Week 14: Lecture 27 – Case studies of farming systems of India
Lecture 28 – Case studies of farming systems of India

***A 6 hour lab exercises per week for hands on practical exercises on the subject**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	The meaning of terms agriculture, domestication and selection.	Literature based historical, sociological and economical aspects of agriculture and diversity of agricultural systems. Field visit to selected agricultural systems.	Internal assessment, assignments, mid-term test and final examination
2.	What are the ecological principles that are	Study of structure and resource flows in agricultural systems.	Internal assessment, assignments, mid-

	applicable in managed ecosystems such as agriculture systems?		term test and final examination
3.	The relationship of domesticated biodiversity with its wild biodiversity?	Literature study on Vavilov centers of origin and visit to gene banks to understand the wild and domesticated diversity.	Internal assessment, assignments, mid-term test and final examination
4.	How ecological problems influence the agriculture and human food security?	Experimentation on stress on production of selected crops. Literature based study on dietary requirements of society and value of energy and nutrients in selected crops.	Internal assessment, assignments, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4010

REPRODUCTIVE BIOLOGY OF FLOWERING PLANTS

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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

Teaching Plan*:

Week 1: Lecture 1 – Diversity in reproductive modes of flowering plants.
Lecture 2 – Temporal and spatial separation of sex expression.

Week 2: Lecture 3 –Floral contrivances and outbreeding devices
Lecture 4 – Pollination syndromes

Week 3: Lecture 5 – Male sterility and application in agriculture.
Lecture 6 – Regulation of pistil and ovule development.

Week 4: Lecture 7 – Evolution of self-incompatibility.
Lecture 8 – Double fertilization; origin, mechanism.

Week 5: Lecture 9 – In vitro fertilization; preferential fertilization.
Lecture 10 – Floral display, attractants and rewards.

Week 6: Lecture 11 – Foraging behavior of pollinators, pollination efficiency.
Lecture 12 –Pollination energetics, applied pollination ecology

Week 7: Lecture 13 – Mating systems
Lecture 14 – Diversity in sexual systems

Week 8: Lecture 15 – Evolution of dioecy, sex determination mechanisms
Lecture 16 – Embryogenesis and embryonic pattern formation

Week 9: Lecture 17 – Endosperm development and differentiation, suspensor
Lecture 18 – Seed development: pattern, gene expression and imprinting

Week 10: Lecture 19 - Agamospermy and parthenocarpy
Lecture 20 – Embryo and endosperm culture

Week 11: Lecture 21 – Development and diversity of fruit types
Lecture 22 – Dispersal and gene flow

Week 12: Lecture 23 – Abortion of flower, fruits, ovules and seeds.
Lecture 24 – Resource allocation.
Week 13: Lecture 25 – Pseudogamy and autonomous development of endosperm.
Lecture 26 – Evolution and components of apomixis
Week 14: Lecture 27 – Role of synergids in double fertilization
Lecture 28 – Reproductive biology and conservation.

***A 6 hour lab exercises per week for hands on practical exercises on the subject**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the causes and consequences of transition in the reproductive attributes of flowering plants?	Intraspecific variation in flowers and correlation with predictors of breeding system and pollination syndromes.	Practical exams
2.	What are the theoretical assumptions, and evidences in the evolution of gender in flowering plants?	Floral biological studies in systems that exhibit temporal and spatial separation in gender expression.	Practical exams
3.	How male sterility in plants is naturally or artificially accomplished, and how the mechanism can be used in yield improvement?	Bagging, controlled manual self and cross pollination, tests of pollen viability, fertility to determine male sterility	Practical exams
4.	What are the different stages of concealment of ovules in angiosperms?	Phyologenetic studies based on available databases.	Spotting
5.	Why breakdown in self-incompatibility to self-compatibility does not revert in nature?	Bioassay with known examples of related congeners.	Practical exams
6.	What are dynamics of plant-pollinator interaction?	Field observations and data analysis.	Continuous evaluation
7.	Does the breeding system analysis in a plant truly indicate the relative contribution of	Mating system analysis using DNA markers, use of softwares such as mltr.	Practical exam, assessment tests, problem solving

	selfing and outcrossing?		
8.	Why the development of embryo and endosperm is essentially interdependent, and are their exceptions to this interdependence?	Observations on autonomous and pseudogamous endosperm development	Spotting,
9.	Why the ratio of flowers to fruit and that of ovule to seed is low in flowering plants?	Comparison between taxa with few to multiovulate condition.	Practical exams/ Records
10.	How to differentiate aposporous and sexual modes of reproduction	Ovule clearing techniques using methyl salicylate and chloral hydrate clearing solutions. Use of differential intereference microscopy for imaing ovules	Practical exams, internal assessment

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4011

MOLECULAR INTERACTIONS OF PLANTS WITH SYMBIONTS, PATHOGENS AND PESTS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 defense 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

Teaching Plan*:

Week 1: Lecture 1 – Introduction to biotic interactions with plants.
Lecture 2 – Stages of plant pathogenesis

Week 2: Lecture 3 – Structural and biochemical host defense against pathogens
Lecture 4 – Distinction between necrotrophic and biotrophic pathogens

Week 3: Lecture 5 – Non-host resistance, Basal resistance, PTI and ETI
Lecture 6 – Plant defence against necrotrophs

Week 4: Lecture 7 – Plant defence against biotrophs

Lecture 8 – Systemic acquired resistance- redox changes, role of salicylic acid, NPR1

Week 5: Lecture 9 – Induced systemic resistance

Lecture 10 – Induced resistance signaling pathways, cross-talk between SA- and JA-dependent defense responses

Week 6: Lecture 11 –Developmental biology of arbuscular mycorrhiza

Lecture 12 –Symbiotic plant interactions - mycorrhiza

Week 7: Lecture 13 – Symbiotic plant interactions – root nodule symbiosis

Lecture 14 – Common symbiosis pathway/**first minor exam**

Week 8: Lecture 15 – Recapitulation in theories on chemical ecology and integrated pest management strategies; R gene mediated resistance, Traditional breeding of crops for pathogen and pest resistance

Lecture 16 – Engineering transgenic and smart breeding for disease and pest resistant crops: Tools and Techniques, Case studies for commercially available crops

Week 9: Lecture 17 – Plant secondary metabolites, synthesis and roles in plant defense against biotic stresses, functional coevolution

Lecture 18 – Physical and chemical defenses in plants against pathogens and pests, Molecular patterns associated with recognition of biotic factors

Week 10: Lecture 19 – Introduction to constitutive and induced mechanisms of resistance against pathogens and pests; application in agri-biotechnology

Lecture 20 – Direct and indirect defense responses to herbivory; ecological costs associated with plant defense responses/ **Journal club sessions**

Week 11: Lecture 21 – Tools, techniques and ongoing elucidation of signaling cascades associated with defense responses against plant pathogens and herbivores

Lecture 22 – Aboveground and belowground defense responses of plants to the biotic environment

Week 12: Lecture 23 – Regulation of plant defense mechanisms against complex biotic stress/**Journal Club sessions**

Lecture 24 – Introduction to vector-transmitted plant pathogens, tools and techniques associated with screening vector transmitted plant pathogens

Week 13: Lecture 25 – Plant defense pathways activated in response to vector, virus infections, and associated costs of defending against multiple stresses

Lecture 26 – RNAi mediated disease/pest resistance, novel and emerging technologies for disease/pest resistance

Week 14: Lecture 27 – Engineering multiple transgenes, targeting multiple pests or co-infecting microbes/ **Journal Club Sessions**

Lecture 28 – Countering plant defense mechanisms and implications in agro-ecosystems Case studies on the insect cadherin gene family and potyvirus HC-Pro gene

Facilitating the achievement of Course Learning Outcomes

Unit.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	To understand molecular mechanisms that enable biotic communities to influence plant growth and development, as well as ecological interactions.	Lec-Dem classes on beneficial and pathogenic plant microbes and herbivores. Hands-on training on diversity analyses and molecular characterization of plant pests and pathogens.	Mid-sem examinations, evaluation of individual/group assignments on a regular basis

2.	To apply knowledge of plant interactions with symbionts, pathogens and herbivores to improve plant health.	Journal club sessions* and class discussions on relevant topics, minor class projects using bioinformatics. For e.g., molecular characterization of R/AVR genes/proteins.	Evaluation of self prepared multimedia presentation skills, comprehension skills, ability to work in a group while developing research questions

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4012

IMMUNOLOGY

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 Hrs.**

Course Objectives:
The objective of this module on immunology is to provide a basic understanding of fundamentals 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

Teaching Plan*:

Week 1: Lecture 1 – Basic principles and overview of immunity;
Lecture 2 – Antigen and antibody production
Week 2: Lecture 3 – Antigen and antibody production
Lecture 4 – Cellular interactions in the immune system
Week 3: Lecture 5 – Cellular interactions in the immune system
Lecture 6 – Innate immunity, Complement
Week 4: Lecture 7 – antibody structure and antigen recognition

Lecture 8 – antibody structure and antigen recognition
Week 5: Lecture 9 – Immunoglobulin genes
Lecture 10 – Ig/TCR gene rearrangement and generation of diversity
Week 6: Lecture 11 – Ig/TCR gene rearrangement and generation of diversity
Lecture 12- introduction to immunogenetics and the MHC
Week 7: Lecture 13- antigen recognition by T cells, TCR, co-receptors / First **minor exam**
Lecture 14 – antigen recognition by T cells, TCR, co-receptors
Week 8: Lecture 15 – MHC structure, antigen processing and presentation
Lecture 16 – MHC structure, antigen processing and presentation
Week 9: Lecture 17- Immune response to infectious diseases
Lecture 18: Immune response to infectious diseases
Week 10: Lecture 19: Immune response to infectious diseases
Lecture 20: immunodeficiency and AIDS
Week 11: Lecture 21- immunodeficiency and AIDS
Lecture 22 – Hypersensitivity, transplant rejections, autoimmunity
Week 12: Lecture 23 – Hypersensitivity, transplant rejections, autoimmunity
Lecture 24– Hypersensitivity, transplant rejections, autoimmunity
Week 13: Lecture 25 – Vaccines
Lecture 26- Vaccines
Week 14: Lecture 27 – Evolution of the immune system
Lecture 28 – Evolution of the immune system

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What is immunity and how various factors such as environmental and genetic makeup regulate it, how does immune system evolve?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
2.	What are antigen and antibodies and how do they interact with each other?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
3.	What happens at cellular level when a foreign antigen enters body?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
4.	Various components of immune systems- immunoglobulin, MHC, TCR etc how does body produce them to fight infections?	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam
5.	How does body fight infections at cellular level? Mechanism and bimolecular	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term

	events involved in the process.		exam and final exam
6	Immunodeficiency related diseases, transplant rejections, autoimmunity and vaccines	Through classroom teaching, demonstration and hands on training	Practical examination, group discussions, assignments, mid term exam and final exam

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4013

ADVANCES IN ARCHEGONIATES

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 Hrs.**

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

Course Learning Outcomes:
The students will be learning
1. What are the plant hormones in bryophytes that regulate growth and development?
2. How do bryophytes, pteridophytes and gymnopsperms interact with microorganisms? What are the strategies for conduction of water and photosynthates.
3. Molecular mechanism of desiccation tolerance and bryophyte and pteridophyte model systems.
4. How does the fern gametophyte develop in response to habitat conditions?
5. What are cases of shrinking population and conservation strategies
6. What are the conditions required 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 specificity (1 lecture), Fern adaptation to xeric environment (1 lecture), Development of fern gametophyte (1 lecture), Genetics and reproductive biology of ferns (2 lectures), Problem ferns , their impact and management (1 lecture), Biology of Azolla (1 lecture), Conservation biology (1 lecture)

Unit IV: Genome sequence and insights into Pteridophyte biology, 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 conifers to environmental 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.

Teaching Plan:

Week 1: Lecture 1 – Spore germination, protonema development and Hormonal regulation of gametophyte development
Lecture 2 – Symbiotic associations Bryophytes with microorganisms
Week 2: Lecture 3 – Associations Bryophytes with animals
Lecture 4 – Responses of bryophytes to climate change
Week 3: Lecture 5 – Anispory and sexual dimorphism (1 lecture)
Lecture 6 – Population ecology and population genetics and community ecology
Week 4: Lecture 7 – Mineral nutrition and substratum ecology
Lecture 8 – Structure and function of bryophyte dominated Peatlands
Week 5 Lecture 9 – Phenology and habitat spacificity (1 lecture), Fern adaptation to xeric Environmen
Lecture 10- Genome sequence and insights into bryophytes biology, evolution, genomics,
Week 6:Lecture 11 – Model bryophytes for molecular genomic studies (*Physcomitrella patens*),Photoreceptors and photomorphogenesis in *P. patens*, Molecular insights into developmental cascades,
Lecture 12 – Abiotic (dessication tolerance) and bioticstress responsive mechanisms in bryophytes (*Physcomitrella*, *Tortula*)/ **first minor exam**
Week 7: Lecture 13 – Genetics and reproductive biology of ferns
Lecture 14 – Problem ferns , their impact and managaement
Week 8:Lecture 15 – Genome sequence and insights into Pteridophyte biology
Lecture 16 – Evolution, genomics, Pteridophytes as model plants (*Ceratopteris*, *Selaginella*)
Week 9:Lecture 17 – Molecular mechanism of sex determination (*Ceratopteris*),)
Lecture 18 – Photoreceptors and photomorphogenesis (*Adiantum*, *Ceratopteris*, *Onoclea*
Week 10:Lecture 19- Stress responsive mechanisms in Pteridophytes (*Selaginella*
Lecture 20 – Biology of Azolla
Week 11:Lecture 21– Seed and seedling biology and regeneration potential

Lecture 22 – Evolution of Pollination mechanism/**second minor exam**
Week 12: Lecture 23 – Litter decomposition rate
Lecture 24 – Conifer plantation as seed trap
Week 13: Lecture 25 – Genome sequence and insights into Gymnosperm biology
Lecture 26 – , Gymnosperm evolution, genomics
Week 14: Lecture 27 – Micropropagation, somatic embryogenesis, Synthetic seed technology
Lecture 28 – Acclimatization and adaptive responses of coniferns to environmetnal stresses

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Spore germination, protonema development and Hormonal regulation of gametophyte development, Associations Bryophytes with microorganisms and animals, Responses of bryophytes to climate change, Population ecology and population genetics and community ecology, Anispory and sexual dimorphism, Mineral nutrition and substratum ecology, Structure and function of bryophyte dominated Peatlands	Class room lectures and Practical demonstration, field experiments	Hands on exercises, presentations, assignments, tests
2.	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*)	Class room lectures and Practical demonstration, field experiments	Hands on exercises, presentations, assignments, tests
3.	Phenology and habitat specificity, Fern adaptation to xeric environment, Development of fern gametophyte, Genetics and reproductive biology of ferns, Problem ferns , their impact	Class room lectures and Practical demonstration, field experiments	Hands on exercises, presentations, assignments, tests

	and management, Biology of Azolla, Conservation biology		
4.	Genome sequence and insights into Pteridophyte biology, 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	Class room lectures and Practical demonstration, photographs	Hands on exercises, presentations, assignments, tests
5.	Evolution of Pollination mechanism in gymnopserms, Seed and seedling biology and regeneration potential, Litter decomposition rate, Conifer plantation as seed trap.	Class room lectures and Practical demonstration, field experiments	Hands on exercises, presentations, assignments, tests
6	Genome sequence and insights into Gymnosperm biology, evolution, genomics, Micropropagation, somatic embryogenesis, Synthetic seed technology, Acclimatization and adaptive responses of conifers to environmental stresses.	Class room lectures and Practical demonstration, visit to gene bank and museum	Hands on exercises, presentations, assignments, tests

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4014

IN VITRO TECHNOLOGIES AND INDUSTRIAL APPLICATIONS

Marks: 150 (Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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: Exposure 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. Ashhara, A., Crozier, A. and Komamine, A. (2011). Plant Metabolism and Biotechnology. John Wiley and Sons, England (UK).
2. Buchanan, B.B., Gruissem, W. and Jones, R.L (2015). Biochemistry and molecular biology of plants. John Wiley and Sons Ltd., UK.
3. Butenko, R.G. (2000). Plant Cell Culture, University Press of Pacific.
4. Davies, P.J. (2004). Plant Hormones, Kluwer Academic Publishers, Netherlands.
5. George, E.F., Hall, M.A. and De Klerk, G.J. (2008). Plant Propagation by Tissue Culture (3rd Edition), Springer, Netherlands.
6. Halford, N. (2006). Plant Biotechnology- Current and future applications of genetically modified crops. John Wiley and Sons, England.
7. Herman, E.B. (2008). Media and Techniques for Growth, Regeneration and Storage 2005- 2008. Agritech Publications, New York, USA.
8. Kayser, O. and Quax, W.J. (2007). Medicinal Plant Biotechnology, From Basic Research to Industrial Applications, Vol. I &II. Wiley-VCH, Weinheim.
9. Kirakosyan, A. and Kaufman, P.B. (2016). Recent Advances in Plant Biotechnology. Springer, UK.
10. Nakar, R.N., Dhaduk, H.L. and Chovatia, V.P. (2016). Medicinal plants- Cultivation and Uses, Daya Publishing House, India.
11. Pierik, R.L.M. (1999). In Vitro Culture of Higher Plants. Kluwer Academic Publishers.
12. Prakash, J. and Pierik, R.L.M. (1991). Horticulture - New Technologies and Applications (Current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.
13. Primrose, S.B. and Twyman, R.M. (2016). Principles of Gene Manipulation, 8th edition, John Wiley and Sons Ltd., Chicester, UK.
14. Ricroch, A., Chopra, S. and Fleischer, S.J. (2014). Plant Biotechnology: Experiences and future prospects, Springer International Publishing AG, Springer, Switzerland.
15. Slater, A; Scott, N.W. and Fowler, M.R. (2012). Plant Biotechnology, the Genetic Manipulation of Plants. Oxford Univ. Press, Oxford.
16. Stewart Jr, C.N. (2008). Plant Biotechnology and Genetics, Principal, techniques and Applications. John Wiley & Sons, USA.
17. Trigiano, R.N. and Gray, D.J. (2011). CRC Press, Taylor & Francis Group, Boca Raton.
18. Loyola-Vargas, V.M. and Ochoa-Alejo, N. (2016). Somatic embryogenesis: Fundamental aspects and applications, Springer International Publishing AG, Springer, Switzerland.
19. Watt, G. (2014). A Dictionary of Economic Products of India.v.5, Linum to Oyster.
20. Wink, M. (2011). An Introduction to Molecular Biotechnology. Wiley Blackwell, Germany.
21. 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 Cell Tissue and Organ Culture, and other journals related to specific topics.

Teaching Plan*:

Week 1: **Lecture 1**– General introduction of various in vitro techniques relevant to biotech industries

Lecture 2– In vitro regeneration through Organogenesis and Somatic embryogenesis and resource generation of commercially important plant species.

Week 2: **Lecture 3**– Protoplast isolation, Culture and regeneration; Somatic hybridization and its application for crop improvement through case studies.

Lecture 4– Production of virus free plants through meristem culture; Synthetic seeds and cryopreservation for long term germplasm conservation.

Week 3: **Lecture 5**– Embryo rescue technique, Haploids and their role in crop improvement through case studies.

Lecture 6– Insight to Direct and Indirect methods of gene transfer to plants.

Week 4: **Lecture 7**– Genetic transformation of crop plants for improvements of traits such as; herbicide resistant plants (Impt. Case Study)

Lecture 8– Transgenic plants resistant to insect and pests (current perspectives; case

study)

Week 5: **Lecture 9**– Transgenic plants tolerant to abiotic stresses such as; drought, cold
Lecture 10– Transgenic plant tolerant to abiotic stresses such as; salt and metal.

Week 6: **Lecture 11**– Comparison of I^{st}, 2^{nd} and 3^{rd} generation transgenics and their advantages and constraints
Lecture 12– Transgenic plants with nutritionally rich traits (Value addition traits); Golden rice.

Week 7: **Lecture 13**– Nutritionally rich transgenic maize/ tomato, etc.
Lecture 14– Edible vaccines, plants with enhanced modified flower pigments.

Week 8: **Lecture 15**– **First minor exam**
Lecture 16–Genome editing through CRISPR/Cas system

Week 9: **Lecture 17**– Exposures to phytochemical analytical tools such as Principle and working of HPLC, HPTLC,TLC, Column chromatography,etc.

Lecture 18– Principle and working of LC-MS and GC-MS

Week 10: **Lecture 19**– Principle and working of FTIR, Scanning Electron microscopy and Transmission Electron microscopy
Lecture 20– A visit to NBPGR and Phytotron Faacilities at IARI/ TERI/ and Biotech park based on the existing Instituional facilities

Week 11: **Lecture 21**– *In vitro* technology and pharma industries, Plant Secondary metabolites,

Lecture 22– *In vitro* extraction and isolation of bioactive compounds from plants used as antimalarial drugs in pharma indutries e.g. Artemisinin

Week 12: **Lecture 23**– Extraction and isolation of anticancerous bioactive compounds such as; Taxol, psoralen, spilanthol, connessine

Lecture 24– Extraction and isolation of antidiabetics bioactive compounds such as steviosides, rebaudiosides

Week 13: **Lecture 25**– Knowledge of biosynthetic pathways and Elicitation of compounds through abiotic elicitors (Heavy metals, salicylic acid, jasmonic acids etc.)
Lecture 26– Elicitation of compounds through biotic elicitors (*Piriformospora indica* and *Agrobacterium rhizogenes*)

Week 14: **Lecture 27**– Hairy root culture and their scaling up through bioreactors
Lecture 28– **Second minor exam**

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What are the different modes of in vitro regeneration? How will you validate the genetic fidelity of regenerants needed for industries ?	Development of efficient micropropagation protocols employing seedling and 'elite' germplasm of plants through tissue culture,evaluation of genetic fidelity of micropropagated plants through DNA finger printing	Internal assessment, assignments, mid-term test and final examination
2.	What are the different methods/approaches of genetic transformation and	Strategies for the development of transgenic plants, their validation through biochemical and molecular	Internal assessment, assignments, mid-term test and final

	raising transgenics for quality improvement and value addition ?	analysis. Discussion based case studies on use of transgenic technology for basic and applied research in plants	examination
3.	What are the technologies involved in the extraction, isolation& characterization of plant-based bioactive compounds useful for pharma industries ?	Exposures of different biochemical and analytical tools such as HPLC, TLC, Column Chromatography, HPTLC,GC-MS, LC-MS,FTIR, NMR, etc. In hand training of some techniques based on available equipments.	Internal assessment, assignments, mid-term test and final examination
4.	What are different methods for elicitation and scaling up of bioactive/therapeutic biomolecules through in technology ?	Knowledge of different biosynthetic pathways of important marker bioactive compounds. Elicitation through induction of Hairy root culture and scaling up through bioreactor technology.	Internal assessment, assignments, mid-term test and final examination
5.	What are the current perspectives of different in vitro technologies to the biotech industries ?	Prospects and limitations of the technologies based on case to case studies.	Internal assessment, assignments, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4015

ADVANCED PLANT SYSTEMATICS

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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 of characters; Evaluation of characters. Systematic evidence: Morphology, Anatomy and ultrastructure; Embryology; Palynology; Cytology; Phytochemistry.

Unit III: Molecular Systematics: Plant genomes: nuclear, mitochondrial, chloroplast; Molecular markers; Generating molecular data: restriction site mapping, gene sequencing; Analysis of molecular data: alignment of sequences, methods of phylogeny reconstruction. Phylogenetics: The nature of phylogeny; How we depict phylogeny? The importance of homology, 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.

Teaching Plan*:

Week 1: Lecture 1 – Unit I:Plant systematics: The Components of systematics,
Lecture 2 – Unit I:Major objectives of systematics;Relevance to society and science.

Week 2: Lecture 3 – Unit I:Taxonomic History: Natural systems to cladistics:
Lecture 4 – Unit I:Natural systems; Phyletic systems;Phenetics; Cladistics

Week 3: Lecture 5 – Unit I: The role of field studies; The role of the herbarium. Botanical Nomenclature: Kinds of names
Lecture 6 – Unit I:International Code of Botanical Nomenclature and its rules

Week 4: Lecture 7 – Unit I:Names according to rank; Citation of authors; Priority
Lecture 8 – Unit I: Type method; Naming a new species;Legitimacy; Synonyms

Week 5: Lecture 9 – Unit II: Introduction to the angiosperms: General characteristics
Lecture 10 – Unit II: Evolutionary history; Basalangiosperms and Magnoliids

Week 6: Lecture 11 – Unit II: Basal monocots; Petaloid monocots; Commelinids; Basaleudicots and Caryophyllids; Rosids; Asterids.
Lecture 12 – Unit II: Classification: The components of classification

Week 7: Lecture 13 – Unit II: Characters and their states; Sources ofcharacters; Evaluation of characters.
Lecture 14 – Unit II: Systematic evidence: Morphology, Anatomy and ultrastructure (I) /**first minor exam**

Week 8: Lecture 15 – Unit II: Systematic evidence: Embryology; Palynology;Cytology; Phytochemistry (II)
Lecture 16 – Unit III: Molecular Systematics: Plant genomes: nuclear, mitochondrial, chloroplast

Week 9:Lecture 17 – Unit III: Molecularmarkers; Generating molecular data: restriction site mapping, gene sequencing
Lecture 18 – Unit III: Analysis ofmolecular data: alignment of sequences, methods of phylogeny reconstruction

Week 10: Lecture 19 – Unit III: Phylogenetics: The nature of phylogeny; How we depict phylogeny?
Lecture 20 –Unit III: The importance ofhomology, Polarizing characters of

homology

Week 11: Lecture 21 – Unit III: Rooting Trees; The problem of homoplasy/**second minor exam**

Lecture 22 – Unit III:The plant systematics community: Professional organizations; Work environment; Activities

Week 12: Lecture 23 – Unit IV: Barcoding – markers and their utilization.

Lecture 24 – Unit IV:Analysis of barcode sequences

Week 13: Lecture 25 – Unit IV:Phylogenomics – concepts and principles

Lecture 26 – Unit IV:Whole genome phylogeny and analysis; plastid genome phylogenies

Week 14: Lecture 27 – Unit IV: New skills to be needed for Next Generation Sequence data analysis

Lecture 28 – Unit IV: Comparative transcriptomics; multigenephylogeneies and species delimitation

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	What is Binomial nomenclature? How it is governed by the ICN?	Exercises on naming of plants and typification.	Internal assessment, assignments, mid-term test and final examination
2.	What important morphological characters delineate flowering plants and their classification up-to generic level?	Laboratory exercise, introduction to plant taxa belonging to economically important plant families, morphological characterization of plants provided.	Internal assessment, assignments, mid-term test and final examination
3.	What are phylogenetic trees and their importance in modern biology?	Hands-on training in DNA extraction, amplification and phylogenetic analysis of morphological and molecular characters. Hands-on experience on the instruments used for phylogenetic approach.	Internal assessment, assignments, mid-term test and final examination
4.	What is plant barcoding and role of standard barcode markers used in delineating species?What are the applications of Next generation sequencing in plant systematics?	Laboratory exercise using computer programs on usage of various combinations of barcode markers gives best result in delineating plant species.	Internal assessment, assignments, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4016

ADVANCED EVOLUTIONARY BIOLOGY

Marks: 150(Theory final exam 70 + internal assessment 30 + Practical exam 50**) Duration: 128 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. Post-zygotic and pre-zygotic 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

Teaching Plan

Week 01: Unit I
Week 02: Unit I
Week 03: Unit I
Week 04: Unit I
Week 05: Unit II
Week 06: Unit II
Week 07: Unit III
Week 08: Unit III
Week 09: Unit IV
Week 10: Unit IV
Week 11: Unit IV
Week 12: Unit V
Week 13: Unit V
Week 14: Unit V

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I, II, III	Theoretical and practical familiarity with study of evolutionary processes.	Lectures, laboratory exercises and reading scientific literature	Internal assessment; final examination.
IV, V	Theoretical and practical familiarity with study of evolutionary history	Lectures, laboratory exercises and reading scientific literature	Internal assessment; final examination.
I-V	Reinforcement of skills in population- and tree thinking	Lectures, laboratory exercises and reading scientific literature	Internal assessment; final examination.

MASTER OF SCIENCE IN BOTANY

Semester IV

Course Code: BOT-Elective-4017

DISSERTATION

Marks: 150 (Thesis 75 + external viva-voce 75**) Duration: 128 Hrs.**

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

Course Learning Outcomes:
Students will acquire the following:

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

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

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3051

CLIMATE CHANGE AND ECOSYSTEM FUNCTION

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 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.

Teaching Plan:

Week 1: Lecture 1 – Definition of terms – weather, climate and ecosystem function
Lecture 2 – Ecosystem function – the context and measures
Week 2: Lecture 3 – Climate change over different temporal scales – evolutionary
Lecture 4 – Climate change over different temporal scales – evolutionary

Week 3: Lecture 5 – Climate change over different temporal scales – current
Lecture 6 – Climate change over different temporal scales – current
Week 4: Lecture 7 – Ecosystem function – the classification
Lecture 8 – Ecosystem function – The dynamics
Week 5: Lecture 9 – Ecosystem function – change over temporal scales
Lecture 10 – Ecosystem function – change over temporal scales/**first minor exam**
Week 6: Lecture 11 – Abiotic factors and their impact on ecosystem function
Lecture 12 – Abiotic factors and their impact on ecosystem function
Week 7: Lecture 13 – Anthropogenic disturbances in ecosystem function
Lecture 14 – Anthropogenic disturbances in ecosystem function
Week 8: Lecture 15 – Climate change and its consequences for sea level
Lecture 16 - Climate change and its consequences for sea level
Week 9: Lecture 17 - Climate change and its consequences for rainfall pattern
Lecture 18 - Climate change and its consequences for rainfall pattern
Week 10: Lecture 19 - Climate change and its consequences for hydrological system
Lecture 20 - Climate change and its consequences for hydrological system
Week 11: Lecture 21 - Climate change and its consequences for extreme events
Lecture 22 – IPCC models and future scenarios/**second minor exam**
Week 12: Lecture 23 – Expected impact of climate change – Tundra ecosystem
Lecture 24 – Expected impact of climate change – Tropical ecosystem
Week 13: Lecture 25 – Expected impact of climate change – Marine ecosystem
Lecture 26 – Expected impact of climate change – Freshwater ecosystem
Week 14: Lecture 23 – Expected impact of climate change – Agriculture ecosystem
Lecture 23 – Expected impact of climate change – Urban ecosystem

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	The meaning of terms weather, climate and how variability in weather is distinctly different from climate change.	Definition of terms. Parameters of weather and its diurnal/seasonal variation	Internal assessment, assignments, mid-term test and final examination
2.	The role of greenhouse gases in supporting life on earth and how anthropogenic activities changed the balance of these gases over time.	Role of greenhouse gases to maintain temperatures on this earth and temperature data from earth and oceanic observatories	Internal assessment, assignments, mid-term test and final examination
3.	The past and present climate scenarios and how	Paleoclimatic data collection and assessment methods, tree ring	Internal assessment, assignments, mid-

	these information was derived?	analysis etc.	term test and final examination
4.	What are ecosystem functions and how climate change affects them?	Valuation methods of ecosystem functions	Internal assessment, assignments, mid-term test and final examination
5.	What the climate models of IPCC indicate?	IPCC RCP models and its implications as given in various assessments.	Internal assessment, assignments, mid-term test and final examination

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3052

PLANT DIVERSITY

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 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, Desertification, 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

Teaching Plan:

Week 1: Lecture 1 – Plant diversity and Classification, various Phyla of Plants and their characteristics

Week 2: Lecture 2 – Bacterial diversity, Terrestrial Plant diversity, Marine Plant diversity, Inland water diversity

Week 3: Lecture 3 – Rain Forest ecosystem and plant diversity, Landscape diversity,

Week 4: Lecture 4 – Ecosystem services

Week 5 Lecture 5 – Human Food and Plant diversity

Week 6:Lecture 6 – Biodiversity Hotspots, Keystone species
Week 7:Lecture 7 – Threats to Plant diversity, Plant invasions Deserification, Endangered plants
Week 8:Lecture 8 – Plant Restoration
Week 9:Lecture 9 – Indeginous people and plant diversity
Week 10:Lecture 10 - Traditional plant conservation practices
Week 11:Lecture 11 – Plants in Indian tradition and culture,
Week 12:Lecture 12 – Use and Economic valus of plant diversity
Week 13:Lecture 13 – Tourism and Plant diversity
Week 14:Lecture 14 – Climate change and plant diversity

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Plant diversity and Classification, Levels of biodiversity, various Phyla of Plants and their characteristics (Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms),	Class room lectures and Practical demonstration, experiments, field visits , Institution visits, museu,m and herbarium study	Hands on exercises, PPT, assignments, tests
2.	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,	Class room lectures and Practical demonstration, experiments, field visits , Institution visits, museu,m and herbarium study	Hands on exercises, PPT, assignments, tests
3.	Biodiversity Hotspots, Keystone species, Threats to Plant diversity, Desertification, Endangered plants, Plant invasions, Loss of Plant diversity, Plant Restoration	Class room lectures and Practical demonstration, experiments, field visits , Institution visits, museu,m and herbarium study	Hands on exercises, PPT, assignments, tests
4.	Indigenous people and plant diversity, Traditional plant conservation practices, Plants in Indian tradition and culture, Plant animal interactions	Class room lectures and Practical demonstration, experiments, field visits , Institution visits, museu,m and herbarium study	Hands on exercises, PPT, assignments, tests
5.	Use and Economic values of plant diversity, Tourism and Plant diversity, Climate change and plant diversity	Class room lectures and Practical demonstration, experiments, field visits , Institution visits, museu,m and herbarium study	Hands on exercises, PPT, assignments, tests

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3053

PLANTS, PEOPLE AND WORLD HISTORY

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 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.

Teaching Plan:

Week1	Unit 1
Week 2	Unit 1
Week3	Unit 2
Week4	Unit 2
Week5	Unit 3
Week6	Unit 3
Week7	Unit 4
Week8	Unit 4
Week 9	Unit 5
Week 10	Unit 5
Week11	Unit 6
Week12	Unit 6
Week 13	Unit 7
Week14	Unit 7

Facilitating the achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
1.	How origin of plants and their subsequent terrestrial conquest played a role in eroding earths crust, altering levels of gases in atmosphere, creating new habitats and shaping earths early landscape.	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests. Theory examinations.
2.	How forests and grasslands were formed and how did they influence earths landscape?	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests. Theory examinations
3.	When and how agriculture started? How did a change from a	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests.

	hunter gatherer to a sedenatary life style primed the beginning of human civilization?		Theory examinations
4.	How plants played important role in human migrations and which are the plants that were significant in mass displacements of humans, colonization of one country by another and long distance journeys for trade and commerce.	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests. Theory examinations
5.	How some plants became the instruments or key reasons for political upheavals and even significant revolts in some countries? How ill- informed scientists with political clout can cause havoc with the life of people and scientific policies resulting in major setbacks to the development of nations?	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests. Theory examinations
6.	What are genetically modified organisms and what are the contentious issues involved with their cultivation and utilization? What are the scenarios that are likely to make scientific information and scientists vulnerable and even subservient to market forces?	Theory lectures, tutorials	Tutorials/ assignments, seminars and tests. Theory examinations

7.	Has conventional agriculture become unsustainable and will sooner or later get abandoned? Will there be paradigm shifts in near future in the way the plants are cultivated today? What can be the novel and hitherto unattempted uses of plants?	Theory lectures, tutorials.	Tutorials/ assignments, seminars and tests. Theory examinations.

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3054

SUSTAINABLE DEVELOPMENT

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 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.

Teaching Plan:

Week 1: Lecture 1 – From Malthus to sustainable development
Lecture 2 - Population
Week 2: Lecture 3 – Population impacts
Lecture 4 - Resources
Week 3: Lecture 5 – Environment and sustainability
Lecture 6 – Environment and sustainability
Week 4: Lecture 7 – Challenges and sustainable development – factors
Lecture 8 – Challenges and sustainable development – linkages
Week 5: Lecture 9 – Challenges and sustainable development – linkages

Lecture 10 – Challenges and sustainable development – determinants
Week 6: Lecture 11 - Challenges and sustainable development – determinants
Lecture 12 – Case studies - Agriculture
Week 7: Lecture 13 – Case studies – Urban system
Lecture 14 – Case studies – Mining/**first minor exam**
Week 8: Lecture 15 – Global environmental issues – population
Lecture 16 – Global environmental issues – population
Week 9: Lecture 17 – Global environmental issues – livelihoods
Lecture 18 – Global environmental issues – livelihoods
Week 10: Lecture 19 – Global environmental issues – Energy
Lecture 20 – Global environmental issues – Energy
Week 11: Lecture 21 – Valuing natures' services
Lecture 22 – Valuing natures' services/**second minor exam**
Week 12: Lecture 23 – Global issues
Lecture 24 – Global issues
Week 13: Lecture 25 – Sustainable community indicators
Lecture 26 – Sustainable community indicators
Week 14: Lecture 27 – Global indicators
Lecture 28 – Global indicators

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	The theory of tragedy of commons and definition of sustainable development in various contexts	Malthus theory, economics and ecology discourses and WECD definition of Sustainable Development	Internal assessment, assignments, mid-term test and final examination
2.	The challenges for achieving sustainable development	The linkages of factors and their determinants. Case studies of sustainable development	Internal assessment, assignments, mid-term test and final examination
3.	The global environmental issues and their impact	The population explosion, carrying capacity concept and ecological foot prints/carbon foot prints of nations	Internal assessment, assignments, mid-term test and final examination
4.	The measure and indicator of sustainable development at community, nation and global level	The measures and indicators of sustainable development at community, nation and global levels	Internal assessment, assignments, mid-term test and final examination
5.			

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3055

PLANT CURIOS – FASCINATING PLANTS

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 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: Defense 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, Plants 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.

Teaching Plan:

Week 1: Lecture 1– Plants of extreme conditons with examples, Desert Plants,
Week 2: Lecture 2– Examples of plants of extreme conditons Welwitschia, conifers, Cacti, *Cordiceps*
Week 3: Lecture 3– Aquatic plants Seaweeds, Podostemads,
Week 4: Lecture 4– Alpine and Arctic Plants, mosses, Grasses
Week 5: Lecture 5– Epiphytic Plantrs, Orchids,
Week 6: Lecture 6– Plants of unique morphology, *Amorphophallus*, *Rafflesia arnoldii* . *Cleistocactus* , *Dracaena*, *Hydnora* , *Victoria amazonica*, *Populus tremuloides*, Buttercup
Week 7: Lecture 7– Plant Age : Euphorbia Obesa, Pinus sylvestris, Ficus , Eucalyptus
Week 8: Lecture 8– *Plant size, Lomatia tasmanica,* ,Seqiuoiadendron, Taxodium, Sequoid sempervirens, *Wolffia*
Week 9: Lecture 9– Parasitic Plants, Balanophora , Cuscuta
Week 10: Lecture 10-Plants of unique functions, Insectivorous plants, *Dionaea, Nepenthes, Drosera, Utricularia*, Codariocalyx Motorius. Dancing Grass (Desmodium Gyrans), Mirabilis, Baobab (Adansonia), Selaginella Lepidophylla, Skunk Cabbage
Week 11: Lecture 11- Invasive plants
Week 12: Lecture 12– defence strategies of plants, *Lithops* species, *Dracunculus vulgaris* Himalayan Blackberry, Hippophae,
Week 13: Lecture 13– Poisonous plants, Giant Hogweed, Angel Trumpet, Amanita, Death Camas, Gympie-Gympie, Tree Nettle, Spurge Hogweed, Red Tide Algae
Week 14: Lecture 14– strange pollination mechanisms, Plant efficiencies, *Ficus* , Palms , *Acacia* , Neem, Plant in Worship, Myths

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Plants of extreme conditions, *Welwitschia*, Podostemads, mosses, conifers, Cacti, Seaweeds, Orchids, *Cordiceps*	Class room lectures and Practical demonstration, experiments, herbarium, museum , photogaphs, elearning , video , Institutional visits, field visits	Hands on exercises, PPT, assignments, tests, questionaire, quiz, competition
2.	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*	Class room lectures and Practical demonstration, experiments, herbarium, museum , photogaphs, elearning , video, Institutional visits, field visits	Hands on exercises, PPT, assignments, tests, questionaire, quiz, competition

3.	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	Class room lectures and Practical demonstration, experiments, herbarium, museum , photogaphs, elearning, video, Institutional visits, filed visits, Institutional visits, field visits	Hands on exercises, PPT, assignments, tests, questionaire, quiz, competition
4.	Defense 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	Class room lectures and Practical demonstration, experiments, herbarium, museum , photogaphs, elearning, video, Institutional visits, field visits	Hands on exercises, PPT, assignments, tests, questionaire, quiz, competition
5.	Strange pollination mechanisms, Rare plants, Plant efficiencies, *Ficus*, Palms, *Acacia*, Neem, Plants in Worship, Myths	Class room lectures and Practical demonstration, experiments, herbarium, museum , photogaphs, elearning, video, Institutional visits, field visits	Hands on exercises, PPT, assignments, tests, questionaire, quiz, competition

MASTER OF SCIENCE IN BOTANY

Semester III

Course Code: BOT-Open Elective-3056

PLANTS FOR HUMAN WELFARE

Marks: 75 (final theory exam 50 marks + internal assessment 25 marks) **Duration: 56 Hrs.**

Course Objectives:

The course aims to introduce the plant resources that help human society to sustain and benefit from their use, Knowledge of biodiversity and its importance, Agricultural diversity and biodiversity loss and biodiversity management.

Course Learning Outcomes:

The students will be learning

1. the useful plants to human society
2. identification feature of such resources
3. The students would be able to judge the value of biodiversity and its role in stabilizing the climate and economy. They would know the causes and consequences of loss of biodiversity and planning of conservation strategies.

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:

1. Kochhar, S.L. (2016). Economic Botany. Fifth Edition. Cambridge University Press, UK. ISBN 978-1-316-63822-4. 664pp.
2. Nakar, R.N., Dhaduk, H.L. and Chovatia, V.P. (2016). Medicinal plants- Cultivation and Uses, Daya Publishing House, India.
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. Kayser, O. and Quax, W.J. (2007). Medicinal Plant Biotechnology, From Basic Research to Industrial Applications, Vol. I &II. Wiley-VCH, Weinheim.
5. Watt, G. (2014). A Dictionary of Economic Products of India.v.5, Linum to Oyster.
6. Wink, M. (2011). An Introduction to Molecular Biotechnology. Wiley Blackwell, Germany.
7. Current reviews and research articles published in leading international/ national Journals.

Teaching plan"

Week and Unit	Contents to be covered
Week 1: 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
Week 2: Unit I	**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.
Week 3: Unit I	**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.
Week 4: Unit I and II	**Alcoholic and non-alcoholic beverages:** Tea, coffee, types, processing, uses and improvement. **Medicinal plants :** 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
Week 5, Unit II	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.
Week 6: 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
Week 7: Unit III	Week 8: Unit III : 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
Week 9: Unit III	**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.
Week 10: Mid semester exam	
Week 11: Mid Semester Break	
Week 12, Unit III	**Plants as a source of timber**: e.g., *Tectona grandis, Salix* sp., *Dalberia sisso* (sheesham) and fuel wood, type and resources.
Week 13: Unit IV	**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.
Week 14: Unit IV	**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

Facilitating the achievement of Course Learning Outcomes

	Course Learning Outcomes	**Teaching and Learning Activity**	**Assessment Tasks**
1.	How plants are useful to human beings.	Through writing on Board, PPT presentation and exposure to different plants through field survey.	Through assignments to students on important topics.
2.	Value addition of plants through genetic transformation	Through writing on board, PPT presentation and discussion. Demonstration in the lab.	Discussion and presentation
3.	To learn Preparation of herbal drugs.using different plant parts such as rhizome,root,stem,leaf,fruit,etc.	Laboratory exercise for demonstration and exposures to different tools and techniquesn for extraction of drugs and bioefficacy study.	Giving in hand training and evaluation
4.	Uses of plants as Alternate source of sugars	PPT presentation, Discussion and field survey	Discussion and test.
5.	Uses of Plants as Nonconventional source of energy, biofuels.	PPT presentation and Discussion. Exposure to available plants in the fields.	Field survey and personal interaction.