RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY

TWO YEAR POSTGRADUATE PROGRAMME

M.Sc. BOTANY

(Courses effective from Academic Year 2023-24)

Scheme of Teaching and Examination

As per NEP 2020

PG Degree Program in Affiliated Colleges

for Two Year Choice Based Credit System (Semester Pattern)

Dr. Sushil G-kunjalwar
Board of Studies Botany
chairman.

Scheme of Teaching and Examination for M. Sc. (Botany)

As per NEP 2020 Structure and Credit Distribution of PG Degree Program for Two Year Choice Based Credit System (Semester Pattern) Effective from 2023-2024

Semester I

SN	Course Category	Name of Course	Course Code	Teaching Scheme (hrs.)			Total (Hrs)	Total Credit	Examination Scheme						
				Th	TU	P			Theory				Practical		
									Exam Hrs.	SEE	CIE	Min.	SEE	CIE	Min.
1	DSC	Microbiology, Algae and Fungi	MBO1T01	4	-	-	4	4	3	80	20	40	-	-	-
2	DSC	Bryophytes and Pteridophytes	MBO1T02	4	-	-	4	4	3	80	20	40	-	-	-
3	DSE	Elective 1 (Choose any One) 1. Palaeobotany and Gymnosperms 2. - Equivalent online course	MBO1T03	4	-	-	4	4	3	80	20	40	-	-	-
4	RM	Research Methodology	MBO1T04	4	-	-	4	4	3	80	20	40	-	-	-
5	LAB 1	Microbiology, Algae, Fungi, Plant Pathology, Bryophytes, Pteridophytes)	MBO1P01	-	-	6	6	3	2-6*				50	50	50
6	LAB 2	Palaeobotany, Gymnosperms, Cytology, Genetics, Cell Biology and Research Methodology	MBO1P02	-	-	6	6	3	2-6*				50	50	50
Total				16	-	12	28	22	-	320	80	160	100	100	100
Marks of Theory Component= 400 Marks of Practical Component= 200 TOTAL =600Min.Passing: 200+100=300															

Semester II

SN	Course Category	Name of Course	Course Code	Teaching Scheme (hrs.)			Total (Hrs.)	Total Credit	Examination Scheme						
				Th	TU	P			Theory				Practical		
									Exam Hrs.	SEE	CIE	Min	SEE	CIE	Min
1	DSC	Cytology and Genetics	MBO2T05	4	-	-	4	4	3	80	20	40	-	-	-
2	DSC	Plant Physiology and Biochemistry	MBO2T06	4	-	-	4	4	3	80	20	40	-	-	-
3	DSE	Elective 2 (Choose any one) 1.Cell Biology 2. Equivalent online course	MBO2T07	4	-	-	4	4	3	80	20	40	-	-	-
4	OJT	OJT	MOJ2P01	-	-	8	8	4	3-8*	-	-	-	50	50	50
5	LAB 1	Plant Physiology, Molecular Biology, Plant Biotechnology, Plant Breeding	MBO2P03	-	-	6	6	3	2-6*	-	-	-	50	50	50
6	LAB 2	Plant Development, Reproduction, Taxonomy, Ecology	MBO2P04	-	-	6	6	3	2-6*	-	-	-	50	50	50
Total				12	-	20	**32**	**22**		**240**	**60**	**120**	**150**	**150**	**150**
Marks of Theory Component= 300 Marks of Practical Component= 300 TOTAL =600Min.Passing: 150+150=300															

Semester III

SN	Course Category	Name of Course	Course Code	Teaching Scheme (hrs.)			Total (Hrs.)	Total Credit	Examination Scheme						
				Th	TU	P			Theory				Practical		
									Exam Hrs.	SEE	CIE	Min.	SEE	CIE	Min.
1	DSC	Development and Reproduction	MBO3T08	4	-	-	4	4	3	80	20	40	-	-	-
2	DSC	Angiosperms- I	MBO3T09	4	-	-	4	4	3	80	20	40	-	-	-
3	DSC	Plant Ecology and Conservation Biology	MBO3T10	4	-	-	4	4	3	80	20	40	-	-	-
4	DSE	Elective 3 (Choose any one) 1. Molecular Biology and Plant Biotechnology-I 2. Mycology and Plant Pathology-I 3. Plant Physiology-I 4. Reproductive Biology of Angiosperms 5. Palaeobotany-I 6. Palynology-I 7. Ethnobotany-I 8. Advanced Phycology and Hydrobiology-I	MBO3T11	4	-	-	4	4	3	80	20	40	-	-	-
5	LAB	On electives	MBO3P05	-	-	4	4	2	-	-	-	-	50	50	50
6	RP	Research Project/ Dissertation (Core)	MRP3P01	-	-	8	8	4	-	-	-	-	50	50	50
Total				16	-	12	**28**	**22**		**320**	**80**	**160**	**100**	**100**	**100**
Marks of Theory Component= 400 Marks of Practical Component= 200 TOTAL =600 Min.Passing: 200+100=300															

Semester IV

SN	Course Category	Name of Course	Course Code	Teaching Scheme (hrs.)			Total (Hrs)	Total Credit	Examination Scheme						
									Theory				Practical		
				Th	TU	P			Exam Hrs.	SEE	CIE	Min	SEE	CIE	Min
1	DSC	Angiosperms II	MBO4T12	4	-	-	4	4	3	80	20	40	-	-	-
2	DSC	Molecular Biology	MBO4T13	4	-	-	4	4	3	80	20	40	-	-	-
3	DSC	Plant Biotechnology and Plant Breeding	MBO4T14	4	-	-	4	4	3	80	20	40	-	-	-
4	DSE	Elective 4 (Choose any one) 1. Molecular Biology and Plant Biotechnology-II 2. Mycology and Plant Pathology-II 3. Plant Physiology-II 4. Reproductive Biology of Angiosperms-II 5.. Palaeobotany-II 6. Palynology-II 7. Ethnobotany-II 8. Advanced Phycology and Hydrobiology-II	MBO4T15	4	-	-	4	4	3	80	20	40	-	-	-
5	RP	Research Project / Dissertation (Core)	MRP4P02	-	-	12	12	6	-	-	-	-	100	100	100
Total				16	-	12	**28**	**22**		**320**	**80**	**160**	**100**	**100**	**100**
Marks of Theory Component= 400 Marks of Project Component= 200 TOTAL =600Min.Passing: 200+100=300															

2 Years-4 Sem. PG Degree (88 credits) after Three Year UG Degree or
1 Year-2 Sem PG Degree (44 credits) after Four Year UG Degree

Total Credits for Four Semesters (Two Year Course): 4 * 22 = 88

Total Marks for Four Semesters (Two Year Course): 4 * 600 = 2400

Basket for ELECTIVE (DSE) Category Courses (Botany)

Semester	Course Category	Name of Course	Course Code
I	Elective 1	A. Palaeobotany and Gymnosperms	MBO1T03
		B. Equivalent online course	
II	Elective 2	A. Cell Biology	MBO2T07
		B. Equivalent online course	
III	Elective 3	A. Molecular Biology and Plant Biotechnology I	MBO3T11
		B. Mycology and Plant Pathology I	
		C. Plant Physiology I	
		D. Reproductive Biology of Angiosperms I	
		E. Palynology I	
		F. Palaeobotany-I	
		G. Ethnobotany-I	
		H. Advanced Phycology and Hydrobiology I	
IV	Elective 4	A. Molecular Biology and Plant Biotechnology II	MBO4T15
		B. Mycology and Plant Pathology II	
		C. Plant Physiology II	
		D. Reproductive Biology of Angiosperms II	
		E. Palynology II	
		F. Palaeobotany-II	
		G. Ethnobotany-II	
		H. Advanced Phycology and Hydrobiology II	

Abbreviations:

DSC: Discipline Specific Course, **DSE**: Discipline Specific Elective **SEE:** Semester End Examination, **CIE:** Continuous Internal Evaluation, **OJT:** On the Job Training (Internship/Apprenticeship), **FP:**Field Project, **RM:**Research Methodology, **RP**: Research Project

RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY

TWO YEAR POSTGRADUATE PROGRAMME
M.Sc. BOTANY

(Courses effective from Academic Year 2023-24)

Syllabus

Semester I and II

As per NEP 2020

PG Degree Program in Affiliated Colleges

for Two Year Choice Based Credit System (Semester Pattern)

Dr. S. G. Kunjalwar
BOS. Botany chairman.

Pre-requisites to enrol for the course

The student who has completed the three-year B. Sc. course with Botany (or allied subject) as the major subject with not less than 50% of aggregate marks (45% in case of student from reserved category) or equivalent CGPA from any of the recognised university is eligible to enrol for M. Sc. (Botany) course. However, the student who has completed four-year B. Sc. course [B. Sc. (Honours) as per NEP- 2020] with Botany (or allied subject) as the major subject with not less than 50% of aggregate marks (45% in case of student from reserved category) or equivalent CGPA from any of the recognised university is eligible to enrol directly in semester III of M. Sc. (Botany) course.

Teacher and research project supervisor

In addition to the regular teachers appointed in the department, these courses can be taught by a person having a post-graduate degree in Botany or any other relevant/equivalent subject or having research experience in that particular area. The regular full-time teacher of the department/contributory teacher approved by the university/scientist of government or private research laboratory appointed by university as a contributory teacher and having M. Phil. or Ph. D. degree in Botany or any other relevant/equivalent subject can supervise the research project of the student.

 # On-Job training/Field project

The objective of on-job training/field project is to allow the student to gain vocational training in academics/ research/industry based on plants and allied organisms. It is also aimed to encourage the student to take-up a life-time vocation based on the programme he/she is pursuing. On-job training/field work will also allow the student to work in team and gain experience, which will be helpful in his/her future life.

The student can earn the credits for 'On job training' by working as an apprentice or an intern in an industrial or research organisation of repute working in the area relevant to Botany. Alternatively, the student can take-up a field project in any discipline allied to Botany under the supervision of a recognised teacher of a university/college or a regular scientist in the national laboratory or a recognised private research laboratory. In any case, the student will complete the on-job training/field project during the vacation after the examination of semester II but before the commencement of semester III. If a student wishes to pursue on-job training/field project during the session of semester II, he/she can do so. However, this should be not at the cost of the attendance in the regular classes and other departmental activities during the session.

In order to earn credits, the total duration of on-job training/field project will be 120 hours, which normally can be completed in twenty days by working for 6 hours per day. At the end of the on-job training/field project, the student will submit a report containing the details of the work carried out during the tenure. The report will be signed by the student, his/her

immediate supervisor during the tenure and the Head of the institute/organisation. In addition, the report should contain a certificate (printed on the letter head of the institute/organisation) issued by the Head of the institute/organisation substantiating that the student has worked for 120 hours as an on-job trainee/undertook a field project. The field project will be evaluated by duly appointed examiners by the university. The format of the certificate should be as follows:

Certificate

This is to certify that Mr./Ms. _____has worked as an on-job trainee/undertook a field project in this institute/organisation under the supervision of Dr./Mr./Ms._____from_____ to_____.
He/she has worked for not less than120 hours during this tenure.

Signature

Head of the institute/organisation

The student will be evaluated for the completion of on-job training/field work on the basis of report submitted by him/her and the power point presentation made by him/her in the presence of internal and external examiner during the examination.

[$]Research project

The objective of research project is to train the student in identifying the problem of research, develop the hypothesis, design the experiments/surveys to test the hypothesis, collect & analyse the data and draw conclusions from it. In addition, the aim is also to prepare the student to present the data in various forms such as project report, presentation in conferences & seminars and research paper. Research project is also aimed to prepare the student for doctoral research after the completion of the programme.

The student will have to carry out a research-based project work in the third and fourth semester. The project work may be carried out in the parent department or any other institute. For this the student will be attached to any of the national/regional/private research institute/organization for the duration of the third and fourth semester. If the student is working in the organisation other than the parent department, then it will be the responsibility of the student to attend the classes and other departmental activities in order to be eligible to appear for the examination. The student will be allotted the supervisor in the third semester; after which the student will finalize the topic of the project work in consultation with the supervisor.

The research project of the student will be evaluated on the basis of the project report submitted by him/her and the power point presentation made by him/her in the presence of internal and external examiner during the examination.

^Elective papers

In addition to the mandatory papers, the student has to opt for elective papers in all thesemesters. In semester I and II, the student has to opt either the elective paper taught in the department in offline mode or any other equivalent online course of at least 4 credits offered by NPTEL or any other such platform. The equivalence of such courses will be decided by the departmental committee comprising of the faculty members of the department and chaired by the Head, Dept. of Botany. The student should get the equivalence letter of the course from this committee before enrolling for the course. The student should submit the passing certificate to the Head of the Department in order to include the marks in the marksheet.

The semester III and IV will also have one optional paper each. These two papers will impart a deeper learning in any one of the disciplines of Botany. The student will be allotted any one of the following papers based upon his/her merit and preference.

SN	Semester III	Semester IV
1	Molecular Biology and Plant Biotechnology I	Molecular Biology and Plant Biotechnology II
2	Mycology and Plant Pathology I	Mycology and Plant Pathology II
3	Plant Physiology I	Plant Physiology II
4	Reproductive Biology of Angiosperms I	Reproductive Biology of Angiosperms II
5	Palynology I	Palynology II
6	Palaeobotany-I	Palaeobotany-II
7	Ethnobotany-I	Ethnobotany-II
8	Advanced Phycology and Hydrobiology I	Advanced Phycology and Hydrobiology II

Credit distribution structure for two years PG programme in Botany

Year	Level	Sem	Major		RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
I	6.0	I	14 (2 theory + 2practical)	4	4	-	-	22	PG Diploma (after 3-year degree)
		II	14 (2 theory + 2practical)	4	-	4	-	22	
Cum. cr. for PG Diploma/I year of PG			28	8	4	4	-	44	
Exit option: PG Diploma 44 credits after three-year degree									
II	6.5	III	14 (3 theory + 1practical)	4	-	-	4	22	PG Degree (after 3-year degree)
		IV	12 (3 theory)	4	-	-	6	22	
Cum. cr. for II yearof PG			26	8	-	-	10	44	
Cum. cr. for two-year PG Degree			54	16	4	4	10	88	

M. Sc. Botany Syllabus (Affiliated colleges of the University) as per NEP- 2020

Semester I

Mandatory Paper 1 (MBO1T01): Microbiology, Algae and Fungi

Objectives

- To explore the microbial diversity.
- To study the morphological and reproductive variations in viruses, prokaryotes, algae and fungi.
- To study the systems of classification and evolutionary trends in algae and fungi.
- To study the common plant diseases caused by bacteria, virus and fungi.

Outcomes

- The diversity among the microbes is revealed to the student in the class, laboratory and field.
- The student appreciates the variability among the algae and fungi and also acknowledges their economic importance.
- The student is able to trace the phylogenetic relationship among the algae and fungi.
- The student is conversed with the common diseases of plants and their control measures.

Module I

General Microbiology

Major landmarks in the history of Microbiology. Concept of three domains; Evolution of Eukarya.

Bacteria

Morphology; Ultrastructure; Nutrition; Reproduction; Economic importance; Cyanobacteria- Thallus ultrastructure, reproduction, economic importance, study of typical representatives (*Microcystis, Anabaena, Spirulina, Gloeotrichia, Scytonema*).

Archaea

General account, Ultrastructure; Nutrition; Reproduction; Economic Importance.

Viruses

General account- Morphology; Ultrastructure of Bacteriophage; Life cycle- lytic and lysogenic cycle;Structure and life cycle of retrovirus; Introduction to Viroid and Prions.

Module II

Phycology

Fritch (1945), and Parkers (1988) systems of classification; General characters: Habitat, thallus structure and organization, ultrastructure of cell, cell wall architecture, pigments, flagella, nutrition, reserve food, reproduction [vegetative, asexual, sexual (isogamy, anisogamy, oogamy)].

Life cycle of following forms

Chlorophyta- *Chlorella*,

Charophyta- *Chara*,

Xanthophyta- *Vaucheria*

Bacillariophyta- *Pinnularia* ,

Pheophyta- *Sargassum*

Rhodophyta- *Batrachospermum*

Economic Importance: Algal blooms, algal biofertilizers, algae as food, industrial applications; Contribution of Indian phycologists: M. O. P. Iyengar, G.S. Venkatraman and R.N. Singh.

Module III

Introduction to Mycology

General characters of true fungi and allied group (Hyphal ultrastructure; fungal wall and septa; main growth forms of fungi); Nutritional requirement of fungi (with reference to biotrophs, hemibiotrophs, necrotrophs, saprotrophs, symbionts); Reproduction: Asexual reproduction and comparative account of sexual reproduction in different groups of fungi with reference to reduction in sexually in fungi.

Outline of nomenclature

ICN; Phylogeny and recent taxonomic criteria.

Classification of Fungi

Review of earlier systems in brief; G. C. Ainsworth (1971 – Dictionary of Fungi), Outline of recent fungal classification by N. N. Wijayawardene *et al.* (Mycosphere 11(1): 1060 – 1456.2020).

Heterothallism; Heterokaryosis; Parasexual cycle

Comparative study, classification and evolutionary trends in the following as per G. C. Ainsworthclassification

Division: Myxomycota (Fungi-like organisms): Characteristics of Four Classes Protist characters and general account with specialreference to *Physarium* and *Plasmodiophora*

Division : Eumycota

Subdivision Mastigomycotina: Characterstic features of Two classes. Life cycle of *Phytophthora,*

Subdivision Zygomycotina: Characteristic features of two classes. Life cycle of *Cunninghamella, Entomophthora.*

Module IV

***Mycology contd*.....**

Comparative study, classification and evolutionary trends in the following:

Subdivision Ascomycotina: Characteristics of six classes. Life cycle of *Phyllactinia, Chaetomium*

Subdivision Basidiomycotina: Characteristics of three classes. Life cycle of *Ustilago, Geastrum.*

Subdivision Deuteromycotina: Characteristics of three classes. Life cycle of *Alteranaria, Cercospora.*

Plant Pathology

Symptomology, histopathology, etiology and identification of diseases with reference to following fungal, bacterial and viral diseases (Bacterial Blight of Paddy, Wheat Rust, Bunt of Wheat, Smut of Jowar, Black arm of Cotton, downy mildew of Brassica, Gummosis, Mosaic Virus of Cucurbits and Potato Blight).

(The above-mentioned topics should be taught in the light of the recent developments in thefield)

Suggested Readings

Aggarwal Ashok, Mehrotra, R.S. (2017) Plant Pathology 3rd Edition. McGraw Hill.

Ainsworth, G.C. and A.S. Sussman (eds). The Fungi, An advance Treatise Vol. I, II, III & IV Academic Press, New York.

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Dixson Peter S. (2011) Sea weeds of British Isles. Pelagic.

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Gupta, V.K. and M.K. Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, Ludhiana.

Hoek, Christiaan (1996) Algae: An Introduction Phycology, Cambridge Publications. Lee, R.E. (2018) Phycology Textbook, Cambridge Uni. Press

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John D. Wehr, Robert G. Sheath, John Patrick Kociolek (2015) Freshwater Algae of North America: Ecology and Classification. Academic Press Publication.

John M. Huisman (2006) Algae of Australia. CSIRO Publishing Ilustratede edition. Katarzyna Chojnacka, Grezegorz Schroeder, Izabela Michalak (2007) Unravelling the Algae:

Kavanagh, Kevin (2017) Fungi: Biology and Applications. Wiley-BlackWell.

Kim, Se-kworne (2015) Hand Book of Marine biotechnology and Advances. Elsevier, Pub. Hoek, Cheistian (1996) Algae: An Introduction to Phycology. Cambridge Publication.

Kirk, PM, P.F Cannon, D.W. Minte (2008) Ainsworth Bisbys Dictionary of Fungi, 10th Ed.

Kumar HD (1988) Introductory Phycology. Affiliated East – West Press Ltd. New Delhi. Morris I (1986) Introduction to the Algae. Cambridge University Press , UK.

Lane, Charles R., Beales, Paul, Hughes, Kelvin J.D. (2012) Fungal Plant Pathogens (Principles and Protocols Series). CABI.

Lee, R.E. (2018) Phycology Textbook. 5th Edition, Cambridge University Press.

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Robert A. Samson, Jan Dijksterhuis (2007) Food Mycology: A Multifaceted Approach to Fungi and Food. CRC Press.

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Wat Kinson, Sarah, Carlile, M.J. the Fungi, 3rd Edition (2016) Published By: Academic Press. Maria de Lourdes, T.M Polizeli, Mahendra Rai (2013) Fungal Enzymes. CRC Press.

Watkinson Sarah, M.J. Carline (2016) The Fungi 3rd Ed. Academic Press.

Semester I

Mandatory Paper 2 (MBO1T02): Bryophytes and Pteridophytes

Objectives

- To explore the diversity of lower plants.
- To study the morphological, anatomical and reproductive variations within and among the groups of Bryophytes and Pteridophytes.
- To traverse the probable evolutionary paths in the lower plants.

Outcomes

- The student acknowledges the diversity among lower plants in the class.
- The student develops an insight to correlate the structural variations with the phylogenetic relationship among plants.
- The student understands the importance of lower plants in the ecosystem and the daily life.

Module I

Division Bryophyta [Kingdom IV: Plantae]

General characters; Distribution; Classification; Vegetative propagation in Bryophytes.
Hepaticopsida: Sphaerocarpales– *Sphaerocarpus*; Marchantiales– *Marchantia*, *Targionia*,; Jungermanniales– *Pellia*, *Porella* (*Madotheca*);
Phylogeny- Evolution of gametophyte and sporophyte.

Module II

Division Bryophyta contd…….

Anthocerotopsida: *Anthoceros, Notothylas*

Bryopsida: Sphagnales– *Sphagnum,* Polytrichales– *Polytrichum*; Takakiales– *Takakia*

Fossil Bryophytes; Ecology; Cytology; Regeneration; Economic Importance.

Module III

Division Tracheophyta [Pteridophyta] [Kingdom IV: Plantae]

General Characters; Distribution; Classification; Evolution of stele; Telome theory; Apospory and apogamy; Contributions of Indian Pteridologists– S. S. Bir, D. D. Pant and T. S. Mahabale.

General account of Rhyniopsida– Rhyniales (*Rhynia*); Psilopsida– Psilotales (*Psilotum*); Lycopsida–Lepidodendrales (*Lepidodendron, Lepidophyllum, Stigmaria, Lepidostrobus, Lepidocarpon*); Lycopodiales (*Lycopodium*); Isoetales (*Isoetes*); Evolutionary trends in Lycopsida.

Module IV

Division Trachaeophyta contd…….

General account of Sphenosida– Hyeniales (*Calamophyton, Sphenophyllum, Calamites*); Equisetales (*Equisetum*); Filicopsida– Eusporangiatae- Ophioglossales (*Ophioglossum*);

Coenopteridales (*Botryopteris*); Leptosporangiatae– Filicales (Cyatheaceae– *Cyathea*); General Characteristics of Marsileales and Salviniales; Evolution of sorus in Filicales; Morphological natureof Sporocarp in *Marsilea*; Progymnospermopsida– Concept established by Beck (1960);*Archeopteris* and *Callixylon.*

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Banks, H. P. (1968) The early history of land plants. In Evolution and Environment, ed. E. T. Drake. New Haven: Yale University Press, pp. 77 – 107.

Crum, H. (2001). Structural diversity of bryophytes. University of Michigan Herbarium. Ann. Arbor.

Graham L. E. (1985) The origin of life cycle of land plants. American Scientist 73: 178-186. Graham L. E. (1993) Origin of land plants, Wiley, New York.

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Kato, M. (1988) The phylogenetic relationship of Ophioglossaceae. Taxon :37, 381-86. Lacey, W.A. (1969). Fossil Bryophytes, Biological Reviews, 44:189-205.

Lellinger, D. B. (2002) A modern multilingual glossary of Taxonomic Pteridology, Amer. Fern Soc; Inc.

Mishler, B. D. and S. P. Churchill (1984) A cladistic approach to the phylogeny of the "Bryophytes". Brittonia 36(4): 406 – 424.

Pant, D. D. (1962) The gametophytes of Psitophytales. Proceedings of Summer School of Botany – Darjeeling, eds. P. Maheshwari, B.M. Johri and I.K. Vasil, pp 276-301.

Rydin, C. and N. Wikstrom (2002) Phylogeny of *Isoetes* (Lycopsida) Resolving basal relationship using rbcL sequences. Taxon 51:83-89.

Smith, A.J.E. (1986) Bryophyte phylogeny: Factor fiction? Journal of Bryology, 14: 83 – 9. Surange, K. R. (1966) Indian Fossil Pteridophytes. New Delhi: Botanical Monograph No. 4.

Surange, K.R. (1952) The morphology of *Stauropteris burntislandica.* P. Bertrand and its megasporangium *Benosonites fusiformis* R.Scott. Philosphical Transactions of theRoyal Society of London B, 237, 73 – 91.

Taylor, T. N. (1981) Paleobotany: An introduction to Fossil plant Biology, Mc Graw Hill, New York.

Taylor, T. N. (1981) Paleobotany: An introduction to Fossil Plant Biology. Mc Graw Hill, New York.

Taylor, T.N (1988) The origin of land plants: Some answers, more questions. Taxon, 37: 805-33.

Zimmermann, W. (1952) The main results of the telome theory. Palaeobotanist, 1: 456-70

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Semester I

Elective Paper 3 (MBO1T03): Palaeobotany and Gymnosperms

Objectives

- To explore the diversity of extinct flora and living Gymnosperms in the class.
- To study the morphological, anatomical and reproductive variations within and among the important groups of extinct plants and living Gymnosperms in the class.
- To understand the evolution of Gymnosperms from the lower plants and their subsequent diversification.

Outcomes

- The student is sensitised about the paleoclimate, fossil flora and the process of fossilisation.
- The student acknowledges the diversity among the Gymnosperms in the class.
- The student develops an insight to correlate the structural variations in the extinct and extant plants with the phylogenetic relationships.

Module I

Palaeobotany

Introduction; Plant Fossils– Geological time scale, Palaeoclimate; Methods of preservation; Studying fossil specimens; Age determination; Fossil record– systematics, reconstruction and nomenclature, problems in nomenclature; Applied aspects of Palaeobotany.

Module II

Gymnospermopsida

General account; Comparison with angiosperms; Distribution (living and fossils); classification (Stewarts 1983); Economic importance.

Morphology and evolutionary tendencies in:

Pteridospermales– Lyginopteridaceae (*Calymmatotheca hoeninghausii, Heterangium, Sphaerostoma*); Medullosaceae (*Medullosa, Trigonocarpus*).

Cycadales– Cycadaceae (Fossil history [*Baenia, Nilssonia, Androstrobus*], *Cycas* [Morphology, anatomy, Reproduction]).

Cycadeoidales– Williamsoniaceae (*Williamsonia sewardiana*).

Module III

Gymnospermopsida contd……

Morphology and evolutionary tendencies in:

Ginkgoales– Fossil (*Baiera, Trichopitys*); *Ginkgo* (living fossil): Morphology, anatomy, Reproduction, phylogeny.

Glossopteridales– Glossopteridaceae (*Vertebraria, Glossopteris, Eretmonia* sp., *Lidgettonia, Ottokaria, Scutum*); Pentoxylales– *Pentoxylon, Nipaniophyllum, Sahnia nipaniensis, Carnoconites sp.*; Cordaitales– *Cordaites, Amyelon, Pennisylvanioxylon, Mesoxylon,*

Cordaianthus (*Cardiocarpus* and *Miterospermum*); Caytoniales– Caytoniaceae (*Sagenopteris, Caytonanthus, Caytonia*).

Module IV

Gymnospermopsida contd.....

Coniferales– General characters; Pinaceae: *Pinus* (Morphology, anatomy, Reproduction and interpretations of bract scale and ovuliferous scale); Taxaceae: *Taxus* (Morphology, anatomy, Reproduction and phylogeny); Gnetales, Ehedrales and Welwitschiales– General characters, reproductive structures: *Gnetum* (Morphology, anatomy, reproduction, angiospermic characters); Phylogenetic considerations.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Agashe, S.N. (1995) Palaeobotany, Oxford & IBH, New Delhi.

Arnold, C.A. (1947) Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.

Beck C.B. (1960) Connection between *Archeopteris* and *Callixylon.* Science 131 : 1524 –1525 Beck C.B. (1962) Reconstruction of *Archeopteris* and further considerations of its phylogenetic position. Am. J. Bot. 49: 373 – 382

Beck.C.B (1985) Gymnosperm Phylogeny : A commentary on the views of S.V.Meyen. Bot Rev. 51: 273 – 294

Bhatnagar, S.P. and Moitra A. (1996) Gymnosperms, New Age International Pvt. Ltd., New Delhi.

Bierhorst D.W. (1971) Morphology of vascular plants McMillan, New York.

Biswas, C & Johri, B.N. (2004) The Gymnosperms, Narosa Publishing House, New Delhi.

Bose, M.N., Pal P.K, Harris TM (1984) The *Pentoxylon* plant. Phil. Trans R Soc London B 310: 77 – 108

Chamberlain C.J. (1986) Gymnosperms, structure and Evolution, CBS publishers, New Delhi. Coulter J.M. & Chamberlain C.J. (1978) Morphology of Gymnosperms, Central Book Depot, Allahabad.

Doyle, J.A (2006) Seed ferns and the origin of angiosperms, Journal of Torrey Botanical Soc.133: 169 – 209

Eames, A.J. (1974) Morphology of Vascular plants-lower groups, Tata Mc-Graw Hill publishing Co., New Delhi.

Gifford, E.M and A.S Foster (1989) Morphology and Evolution of Vascular plants, 3rd edition. W.H. Freeman and Co. New York.

Harris T.M (1951) The relationship of the Caytoniates. Phytomorphology 1 : 29 – 39.Harris T.M. (1961) The fossil cycads. Palaeontology, 4:313 – 323.

Kakkar, R.K. and Kakkar, B.R. (1995) The Gymnosperms (Fossils & Living), Central Publishing House, Allahabad.

Konar R.N., Oberoi, Y.P. (1969a) Anatomical studies on *Podocarpus gracilior*. Phyotomorphology 19 : 122 – 133.

Kubitzki K. (1990) The families and genera of vascular plants Pteridophytes and Gymnosperms, Springer Verlag, New York.

Maheshwari P., Vasil Vimla (1961a) *Gnetum* Bot. Monograph No. 1: 1-142. Council. Sci. Ind. Res. (CSIR), New Delhi

Maheshwari, P, Konar R.N. (1971) *Pinus,* Biol. Monograph No. 7: 1-130 Counci Sci Ind Res (CSIR, New Delhi)

Maheshwari, P., Singh (1967) The female gametophyte of gymnosperms. Biol. Review 42 : 88– 130

Mathews, S. (2009). Phylogenetic relationship among seed plants: Persistent questions and the limits of molecular data. American Journal of Botany. 96:228-236.

Pant, D.D. (2003) Cycas and allied Cycadophytes, BSIP, Publications. Pant. DD (1977) The Plant of *Glossopteris* J. Indian Bot. Soc. 56 : 1-23.

Rao A.R. (1981) The affinities of the Pentoxyleae. Paleobotanist 28-29 : 207 -209. Roychowdhury C. (1962) The embryology of Conifers : A Review Phytomorphology 12:313– 338

Sahni B, (1948) The Pentoxylae : A new group of Jursassic gymnosperms from Rajmahal Hills of India. Bot. Gaz. 110 : 47 – 80

Sharma O.P. (2002) Gymnosperms, Pragati Prakashan, Meerut.

Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.

Singh, H. (1978) Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebryder, Bortragear, Berlin.

Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.

Sporne KR (1965) Morphology of Gymnosperms pp 1-216, Hutchinson, London.

Stewart W N (1981) The Progymnospermopsida : The construction of a Concept Canad. J. Bot. 59 : 1539 - 1542

Stewart W.N, G.W. Rothwell (1993) Paleobotany and the evolution of plants. Cambridge uni-press, New York.

Thomas, B.A. & Spicer R.A. (1987) The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Semester I

Research Methodology Paper 4 (MBO1T04)

Objectives

- To sensitize the student about research methodologies & their application.
- To update the student about the concepts of Foundations of Research, Problem Identification & Formulation, Research Design, Qualitative and Quantitative Research, Measurement, Sampling & data collection.

Outcomes

- The students are acquainted with the process of selection of a research problem and techniques and tools to be employed in completing a research project.
- The students are capable of Analysis and Interpretation of Data and Paper Writing.
- The students are acquainted with the skills of qualitative and quantitative data analysis and presentation.
- The students will be abreast with the employability skills required for various academic research & industrial units.

MODULE 1

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method- Understanding the language of Research - Concept, Construct, Definition, Variable. Research Process.

Problem Identification & Formulation: Research Question-Investigation Question – Measurement Issues - Hypothesis- Qualities of a good Hypothesis Null Hypothesis & Alternative Hypothesis. Hypothes is Testing-Logic & Importance.

MODULE 2

Research Design: Concept and Importance in Research - Features of a goodresearch design- Exploratory Research Design - concept, types anduses, Descriptive Research Designs - concept, types and uses. Experimental Design:Concept of independent & dependent variables.

Qualitative and Quantitative Research: Concept of measurement, causality, generalization, replication.Merging the two approaches.

MODULE 3

Measurement: Concept of measurement-what is measured? Problems in measurement in research Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio.

Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample-Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample-Practical considerations in sampling and sample size.

Data Analysis: Data Preparation-Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis- Cross tabulations and Chi-square test including testing hypothesis ofassociation.

MODULE 4

Interpretation of Data and Paper Writing- Layout of a Research Paper, Journalsin Computer Science, Impact factor of Journals, When and where to publish? IPR- Types, Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Software for detection of Plagiarism

Use of Encyclopedias, Research Guides, Handbook etc., Use of academic Databases Inflibnet, eShodhsindhu, eShodhganga, NCBI, CSH etc.

Use of tools & techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/ Mendeley, Software for paper formatting like LaTeX/MSOffice

Suggested Reading

Research Business Research Methods- Donald Cooper & Pamela Schindler, TMGH, 9th editions.

Business Research Methods- Alan Bryman & Emma Bell, Oxford University Press.

Research Methodology- C. R. Kothari

Select references from the Internet

Proforma question paper for the external assessment of the student in the mandatory and elective theory papers at the end of each semester

Time: 3 hrs. Max. marks: 80

Note: All questions are compulsory and carry equal marks. Draw labelled diagrams wherever necessary.

1. A long answer question from Module 1. 16

OR

Write notes on:

a. A short answer question from Module 1.
b. A short answer question from Module 1.

2. A long answer question from Module2. 16

OR

Write notes on:

a. A short answer question from Module 2.
b. A short answer question from Module 2.

3. A long answer question from Module 3. 16

OR

Write notes on:

a. A short answer question from Module 3.
b. A short answer question from Module 3.

4. A long answer question from Module 4. 12

OR

Write notes on:

a. A short answer question from Module 4.
b. A short answer question from Module 4.

5. Write short notes on: 12

a. A very short answer question from Module 1.
b. A very short answer question from Module 2.
c. A very short answer question from Module 3.
d. A very short answer question from Module 4.

Semester I

Mandatory Lab 1 (MBO1L1): Microbiology, Algae, Fungi, Plant pathology,Bryophytes, Pteridophytes

Objectives

- To explore the diversity of microbes and lower plants in laboratory and field.
- To study the morphological and reproductive variations in Cyanobacteria, algae, fungi, bryophytes and pteridophytes.
- To study the common plant diseases caused by bacteria, virus and fungi.

Outcomes

- The diversity among the microbes and lower plants is revealed to the student in the laboratory and field.
- The student appreciates the variability among the microbes and lower plants and also acknowledges their economic importance.
- The student is conversed with the common diseases of plants and their control measures.

Microbiology and Algae

Classification and type study of the following Cyanobacteria and classes of algae
Cyanobacteria: *Microcystis, Nostoc, Anabaena, Lyngbya, Spirulina, Gloeotrichia, Stigonema* Prochlorophyta: *Prochloron*; Chlorophyta: *Pandorina, Eudorina, Stigeoclonium, Ulva, Chlorella, Scenedesmus, Caulerpa, Valonia, Acetabularia*; Pheophyta: *Spacelaria, Padina, Turbinaria*; Rhodophyta: *Nemalion, Gelidum, Gracilaria, Corallina, Polysiphonia*; Euglenophyta: *Euglena, Phacus*; Bacillariophyta: *Cyclotella, Synedra, Cymbella, Navicula,Gomphonema.*

(One long and one short Botanical excursions are compulsory.)

Fungi and Plant pathology

Morphological Studies of Fungi (any 15 of the following)

1. Identification of fungal cultures, slides and specimens of:
   Stemonities, Perenospora, Phytopthora, Albugo, Mucor, Rhizopus, Yeast, Aspergillus, Penicillium, Chaetomium, Taphrina, Peziza, Erisyphe, Phyllactenia, Uncinula, Melamosora, Uromyces, Drecheslera, Ravenallia, Ustilago, Polyporus, Morchella, Cyanthus, Alternaria, Helminthosporium, Curvularia, Colletotrichum, Phoma, Plasmodiphora, Cercospora, Fusarium, Claviceps.
2. Isolation, identification and enumeration of AM? Fungal spores from soil.
3. Tools and techniques for studying Fungi.
4. Measuring the dimension of microorganisms using micrometry.
5. Preparation of culture media.
6. Study of symptomology of the following fungal diseases by taking sections and slide preparation: (any 7 of the following).
   White rust of Crucifers, Downy mildew, powdery mildew, Rusts, Smuts, Ergot, Groundnutleaf spot (Tikka disease), False smut of paddy, red rot of Sugarcane, Wilt disease, Citrus canker, Angular leaf spot of cotton, Potato blight, Leaf mosaic of bhindi/Papaya, Leaf curlof tomato /Potato, Little leaf of brinjal.
7. Identification of Fungal cultures (Any 5)
   Rhizopus, Mucor, Cunnighamella, Syncephalastrum, Aspergillus, Penicillum, Drechslera, Curvularia, Fusarium, Phoma, Colletotrichu, Alternaria, Helminthosporium, Chaetomium.

Field study: Collection of infected plant material and studying fungal flora.(One long and one short Botanical excursions are compulsory.)

Bryophytes

Sudy of morphological and reproductive characters of representative members mentioned in the syllabus using clear whole mount preparations and by taking T.S. and L.S. Preparation of permanent slides is necessary.

Material to study: *Riccia, Marchantia, Plagiochasma, Fimbriaria, Dumortiera, Porella, Pellia, Sphagnum, Polytrichum* and *Pogonatum.*

(One long and one short Botanical excursions are compulsory.)

Pteridophytes

Study of fossil forms *(Specimens and Micropreparations)*: *Botryopteris Zygopteris, Callixylon, Calamites.*

Study of living forms: Morphology, anatomy and reproductive characters. Anatomical characters to be studied by taking free hand section (T.S/ L.S). Preparations and observation of permanent slide is necessary.

Material to study: *Psilotum* (Museum specimens and permanent micropreparations), *Lycopodium, Selaginella, Isoetes, Ophioglossum, Cyathea, Salvia, Azolla, Marsilea.*

(One long and one short Botanical excursions are compulsory.)

SEMESTER I

Lab 1 (MBO1L1): Microbiology, Algae, Fungi, Plant pathology, Bryophytes, and Pteridophytes

Time: 6 hours Full marks: 100

Q. 1 To identify the given Cyanobacterial material **A**.	4
Q. 2 To identify two algal forms **B**, **C**, from the given mixture.	6
Q. 3 To identify the given fungal culture **D**.	5
Q. 4 To identify the given plant pathogen in the given material **E**.	5
Q. 5 To prepare a permanent microprepration of the given Bryophytic material **F** and identify it.	10
Q. 6 To prepare a double stained permanent microprepration of the given Pteridophytic material **G** and identify it.	10
Q. 7 Comment on the given spot **H** (Cyanobacteria/Bacteria/Algae), **I** (Fungi/Plant pathology), **J** (Bryophyte), **K** (Pteridophyte).	10
Q. 8 Viva-voce.	25
Q. 9 Practical record and tour report.	25

Semester I

Mandatory Lab 2 (MBO1L2): Palaeobotany, Gymnosperms, Cytology, Genetics, Cell biology and Research Methodology

Objectives

- To study the fossil specimens in laboratory and field.
- To study the morphological, anatomical and reproductive variations within and among the living Gymnosperms in laboratory and field.
- To gain hands-on experience in the fundamental techniques of cytology and genetics.
- To gain hands-on experience in basic techniques used in cell biology.
- To study the effect of stress in plants.

Outcomes

- The student is sensitised about the fossil flora.
- The student acknowledges the diversity among the Gymnosperms the laboratory and field.
- The student is equipped with techniques to prepare stains and study chromosomes and to analyse the data to decipher underlying genetical phenomenon.
- The student is equipped with the techniques to isolate and quantify DNA.
- The student is conversant with the technique to evaluate the effect of stress on plants.

Palaeobotany and Gymnosperms

Comparative study of vegetative and reproductive parts: *Cycas, Pinus, Cryptomeria, Taxodium, Thuja, Gnetum, Ginkgo.* Preparation of permanent micropreparations of T.S, R.L.S and T.L.S. of stem, anatomy of leaf, reproductive organs.

Study of fossil gymnosperms from specimens and permanent slides. Visit to palaeobotanical institutes and localities.

(One long and one short Botanical excursions are compulsory.)

Cytology and Genetics

1. To Prepare acetocarmine stain for cytological studies.
2. To fix the onion root tips and onion buds for the cytological studies.
3. To study the mitotic cell division in the given material.
4. To study the meiotic cell division in the given material
5. To study the effect of mutagen treatment on seed germination and seedling height in the given material.
6. To study effect of mutagen on the rate of mitotic cell division in the given material.
7. To study induction of chromosome aberrations by the mutagen in the given material.
8. To study the translocation heterozygote in *Rheo discolor* or any other suitable material.
9. To study polytene chromosomes in *Chironomas* larvae.
10. To study the karyotype of the given organism.
11. To study the chiasma frequency in the given material.
12. To study the pollen fertility in the given plant material.
13. To solve the given problems on interaction of genes (at least five).
14. To solve the given problem on population genetics (at least three).

Cell biology

1. To demonstrate the semi-permeability of the plasma membrane.
2. To study the chemistry of the plant cell wall by the cytochemical methods.
3. To isolate the plant DNA by CTAB method and to check its purity.
4. To quantify the DNA in the given sample by diphenylamine reagent method.
5. To study the activity of PAL in the seedlings challenged with the elicitors.
6. To study the induction of antioxidant enzymes in the seedlings challenged with elicitors.
7. To study the effect of water stress on the growth of seedlings.
8. To study the effect of water stress on the chlorophyll content of seedlings.
9. To study the effect of temperature stress on the growth of seedlings.
10. To study the effect of temperature stress on the chlorophyll content of seedlings.
11. To study the effect of salt stress on the growth of seedlings.
12. To study the effect of salt stress on the chlorophyll content of seedlings.
13. To study the structure of biological membrane, cell organelles and cell junctions from electron micrographs

SEMESTER I

Lab 2 (MBO1L2): Palaeobotany, Gymnosperms, Cytology, Genetics, Cell biology and Research Methodology

Time: 6 hours Full marks: 100

Q. 1 To prepare a double stained permanent microprepration of the given Gymnospermic material **A** and identify it. 10

Q. 2 Comment on the given fossil specimen **B**. 5

Q. 3 To prepare the squash of the given material **C** and identify the stage of cell division. 5

Q. 4 To perform the given exercise on Cytology and Genetics **D**. 8

Q. 5 To perform the given Cell biology experiment **E**. 12

Q. 6 Comment on the given spot **E** (Gymnosperms), **F** (Cytology), **G** (Genetics), **H** (Cell biology). 10

Q. 7 Viva-voce. 25

Q. 8 Practical record and tour report. 25

Semester II

Mandatory Paper 5 (MBO2T01): Cytology and Genetics

Objectives

- To study the phenomenon of inheritance and principles of population genetics.
- To study the structure and organization of a typical and special chromosome.
- To study the chromosomal variations and their effect on the organisms.
- To study the nature, effect and applications of mutations in plants.

Outcomes

- The student interprets the observations in nature in the light of laws of genetics and/orunderlying cytological aspects.
- The student employs the knowledge of Genetics and induced mutations for crop improvement.

Module I

Inheritance

Mendel's laws of inheritance: History, monohybrid and dihybrid ratio, criticism of Mendel's work; Deviations from Mendel's findings: incomplete dominance, co-dominance, penetrance, expressivity (effect of temperature & humidity, gene action- gene dosage in bobbed mutants, gene controlled processes in flour moth & Beadle and Tatum's experiment in *Neurospora*), multiple alleles and isoalleles, lethal alleles, gene interactions (non-epistatic and epistatic), Linkage; Chromosome theory of inheritance; Modifier, suppressor and pleiotropic genes.

Cytoplasmic inheritance: Killer and sensitive strains of *Paramecium*, leaf variegation in *Mirabilis jalapa*, streptomycin resistance in *Chlamydomonas*, male sterility in higher plants, petite mutations in yeast; Maternal effect: Coiling of shell in snails.

Module II

Inheritance contd...

Sex-influenced characteristics: Beard in goats; Sex-limited characteristics: Cock feathering;Sex determination in plants, *Drosophila* and *Caenorhabditis elegans*.

Chromosomes

Chromosome structure and packaging of DNA; Molecular organization of centromere and telomere; rRNA genes; Euchromatin and heterochromatin; Banding patterns; Special types of chromosomes: Polytene, Lampbrush and B-chromosome; Karyotype analysis and evolution; Molecular basis of chromosome pairing.

Module III

Structural variation in chromosomes

Deficiency & deletion; Duplication; Translocation: Cytology and breeding behaviour of translocation heterozygote, complex translocation heterozygotes, translocation tester sets, Robertsonian translocation, interchange heterozygosity in *Oenothera*; Inversion: Cytology and genetic consequences on inversion, overlapping inversions, inversions in *Drosophila* population.

Heteroploidy (Numerical variations in chromosomes) Aneuploidy: Monosomy, nullisomy, trisomy- trisomics of Datura, Down's syndrome and production of trisomics, tetrasomy; Euploidy: Monoploid and haploid- Origin, cytology, uses and production, Polyploidy- Autopolyploid (origin, production, cytology, Genetics and uses), Allopolyploid (evolution of wheat, synthesized allopolyploids and Triticale), Autoalloploidy, induction of polyploidy.

Population genetics

Genotypic and allelic frequencies; Hardy-Weinberg equilibrium: The law, its implications and extensions, testing the Hardy-Weinberg proportions and estimating the allelic frequencies; Factors affecting Hardy-Weinberg equilibrium: Non-random mating, mutation, migration,genetic drift and natural selection.

Module IV

Quantitative trait loci

Pure lines of Johannsen; Kernel colour in wheat and corolla length in *Nicotiana longifera*.

Mutations

Definition; Types: Point, chromosomal, genome and extra-chromosomal; Nature: Spontaneous and induced; Physical mutagens: Characteristics, types, mode and molecular basis of action (Target theory); Chemical mutagens: Types, mode and molecular basis of action, factors affecting the chemical mutagenesis; Role of mutations in crop improvement.

Epigenetics

Introduction: Definition, histone code, base modification, effect on RNA molecules; Effect of epigenetic processes: *MEDEA* of *Arabidopsis*, Paramutations in maize, changes induced by maternal behaviour in mice, effects of early stress and effects in cognition; Callipyge sheep; Epigenetics and Lamarckism; Epigenome and epigenomics (overview).

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Dnyansagar VR 1986 Cytology and Genetics. Tata McGraw-Hill, New York.

Gardiner EJ, Simmons MJ, Sunustad DP 2005 Principles of Genetics 8e. John Wiley and Sons(Asia) Pte. Ltd., Singapore.

Gupta PK 2007 Genetics: Classical to Modern. Rastogi Publications, Meerut.

Hanlon SL, Miller DE, Eche S, Hawley RS 2018 Origin, composition and structure of the supernumerary B chromosome of *Drosophila melanogaster*. Genetics 210(4): 1197- 1212. DoI: https://doi.org/10.1534/genetics.118.301478

Hartl DL, Jones EW 2006 Genetics: Principles and Analysis 4e. Jones and Barflett Publishers,USA.

Hexter W and Yost Jr. HT 1977 The Science of Genetics. Prentice Hall of India Pvt. Ltd., NewDelhi.

Houben A 2017 B- Chromosomes- A matter of chromosome drive. Frontiers in Plant Science 8: 210. DoI: https://doi.org/10.3389/fpls.2017.00210

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Pierce BA 2017 Genetics: A conceptual approach 6e. W H Freeman and Company, USA.

Russell PJ 2010 Genetics: A molecular approach 3e. Pearson Benjamin Cummings, USA.

Snustad DP, Simmons MJ 2015 Principles of Genetics 7e. John Wiley and Son Inc., USA.

Van Harten AM 1998 Mutation breeding- Theory and Practical application. Cambridge

Review articles and Research papers Camacho JP, Sharbel TF, Beukeboom LW 2000 B-chromosome evolution. Philos. Trans. R Soc. Lond. B Biol. Sci. 355(1394): 163–178. DoI: 10.1098/rstb.2000.0556

University Press, UK.

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Semester II

Mandatory Paper 6 (MBO2T02): Plant Physiology and Biochemistry

Objectives

- To get an in-depth view of the biological processes occurring in the plants and the factorsaffecting the plant life.
- To understand the nature and mechanism of enzyme action.
- To understand the structure and role of the major molecules in plant cells.

Outcomes

- The student realises the role and mechanism of physical and chemical factors affecting theplant life.
- The student learns about the diversity of the biological molecules.
- The student develops strategies to mitigate the adverse effect of environmental stresses onplants.

- The student learns to manipulate the physiological processes to enhance the crop yield andfor crop improvement.

Module I

Water relations

1. Carbohydrates: Structure and function; Sterioisomerism
2. Lipid : Structure and function of lipids, Odd & Even chain fatty acids, membrane & storage lipids.
3. Amino acids & Protein : Structure, Primary, secondary, tertiary and quaternary structure of Protein, Ramchandra plot.
4. Enzymes: Nomenclature and classification, Mechanism of Enzyme action, Enzyme kinetics Michaelis –Menten equation, Regulation of Enzyme activity, Activators & Inhibitors, Types of Inhibition, isozymes.

ATP Structure & Chemiosmosis

Module II

1. Photosynthesis:

Evolution of photosynthetic apparatus, pigments, Light, light harvesting complex, Light dependent phase, Photo protective mechanism, Light Independent Phase , Photorespiration, C4 and CAM pathway; synthesis of starch and Sucrose

2. Respiration:- Glycolysis, Citric acid cycle, Plant mitochondrial electron transport and ATP synthesis (oxidative phosphorylation); oxidative pentose phosphate pathway, beta oxidation
3. Fatty acid biosynthesis Conversion of storage lipids into carbohydrates during germination.

Module III

1. Plant hormones:- biosynthesis, storage , breakdown and transport of hormones, physiological

effect and mechanism of action of hormones auxins, gibberellins and cytokinin

2. Sensory photobiology:- Phytochromes: Pr and Pfr forms, location, responses of various types of phytochromes, signalling pathways; Blue-light responses; Cryptochromes; Phototropins; Flowering: Circadian rhythms, Photoperiodism (including molecular aspects), vernalization, florigen.

Module IV

1. Amino acid biosynthesis in Plants.
2. Nitrogen metabolism: Nitrate and ammonium assimilation, Root microbe interaction & biological N Fixation
3. Secondary metabolites: Biosynthesis of terpenes, phenols. Nitrogenous compounds and their roles
4. Nucleotides: Structure; Biosynthesis: *de novo* and salvage pathways and regulation

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Bhatla SC, Lal MA 2018 Plant physiology, development and metabolism. Springer NatureSingapore Pte. Ltd., Singapore.

Buchanan BB, Gruissem W, Jones RL 2015 Biochemistry and Molecular Biology of plants 2e.

Wiley and American Society of Plant Physiologists, USA.

Conn EE, Stumpf PK, Bruening G, Doi RH 1987 Outlines of Biochemistry 5e. John Wiley &Sons, Singapore.

Hopkins WG 1995 Introduction to Plant Physiology. John Wiley & Sons, Inc., USA.Jain JL, Jain S, Jain N 2016 Fundamentals of Biochemistry. S. Chand, India.

Jones R, Ougham H, Thomas H and Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA.

Lodish H, Berk A, Zipursky SL, Matsudaira P, Baltimore, D, Darnell J 2018 Molecular CellBiology 6e. W. H. Freeman and Company, USA.

Nelson DL, Cox MM 2021 Lehninger Principles of Biochemistry 8e. Macmillan, USA.

Nobel PS 1999 Physicochemical and Environmental Plant Physiology 2e. Academic Press,USA.

Salisbury FB, Ross CW 1992 Plant Physiology 4e. Wadsworth Publishing Co., USA.

Singhal GS, Renger G, Sopory SK, Irrgang KD, Govindjee 1999 Concepts in Photobiology,Photosynthesis and Photomorphogenesis. Narosa Publishing House, India.

Taiz L, Zeiger E, Moller IM, Murphy A 2015 Plant Physiology and Development 6e. SinauerAssociates, Inc., USA.

Thomas B, Vince-Prue D 1997 Photoperiodism in Plants 2e. Academic Press, USA.Recent issues of the relevant 'Annual Reviews' should also be consulted.

Semester II

Elective Paper 7 (MBO2T3): Cell biology

Objectives

- To study the ultrastructure and function of the cell envelope, organelles and cytoskeleton.
- To study the structure, replication and repair of DNA.
- To study the cellular responses of plants towards the stresses.

Outcomes

- The student is acquainted with the details of the structure and role of the cell organelles.
- The student is acquainted with the structure of DNA and the mechanisms involved in its replication and protecting its structure.
- The student is equipped with the effect of stress on plants.
- The student is able to devise the strategies to mitigate the adverse effect of the stress on the plants.

Module I

Plant cell wall

Overview of the structure; Chemistry: Sugars, Polysaccharides, Structural proteins, Aromatic substances; Primary cell wall of Angiosperms: Architecture, Biosynthesis, Growth, Locking; Fruit ripening; Secondary cell wall of Angiosperms: Structure, Diversity, Functions, Commercial importance.

Membranes

Membrane architecture: Historical aspects, Fluid mosaic model; Membrane lipids; Membrane proteins; Membrane carbohydrates; Membrane fluidity; Membrane transport: Passive (simple diffusion, diffusion through channel and facilitated diffusion), Active (P-type pumps, V-type pumps, ABC transporters, light as the source of energy for transport, cotransport).

Module II

Cell junctions

Gap junction: Structure, Role and Diversity of proteins; Plasmodesmata: Structure and Role.

Nucleus

Hammerling's experiment with *Acetabularia*; Ultrastructure: Nuclear envelope, Nuclear pore complex, nuclear lamina, Nucleoplasm; Nucleolus; Function.

DNA

DNA as the genetic material: History, Griffith's experiment, Hershey and Chase's experiment; Watson and Crick model of DNA; Different forms of DNA; DNA supercoiling; DNA replication: Messelson and Stahl experiment, DNA polymerases (bacterial and eukaryotic), Replication in bacterial and eukaryotic cells; DNA repair: DNA damage, Repair systems (Direct repair [Photoreactivation], Mismatch repair [BER & NER], Recombination repair), error-prone repair and mutator phenotypes, controlling direction of mismatch repair, recombination repair systems in *E. coli*, recovery of replication errors by recombination, SOS system, eukaryotic repair systems, NEHJ pathway.

Module III

Cell organelles

Ultrastructure and functions: Endoplasmic reticulum (details of protein trafficking not required), Golgi complex (details of protein trafficking not required), Lysosomes, Vacuoles; Peroxisomes; Endocytic pathway.

Cytoskeleton and cell motility

Introduction to cytoskeleton; Intermediate filaments; Actin, tubulin introduction of kinesin & dienins: Gene families, Polymerization, Characteristics; Cytoskeletal accessory proteins; Role of actin in directed intracellular movements; Cortical microtubules; Role of cytoskeleton in mitosis and cytokinesis

Module IV

Definition and classification of stress.

Biotic stress

Host-parasite relationship; Passive defense mechanism: Physical and Chemical barriers;

Active defense mechanism: Early response (Changes in membrane function, Oxidative burst, Cell wall reinforcement, HR, Phytoalexin synthesis), Delayed response (Pathogen containment, wound repair, PR proteins, SAR); Induction of enzymes; Phenylpropanoid mechanism; R-genes.

Abiotic stress

Introduction; Effect of water, temperature, salt and light stress on plants; Mechanisms protecting plants against stresses: Modification of life cycle, changes in leaf, changes in root-to-shoot ratio, stomata, osmotic adjustments, development of aerenchyma, protection from toxic ions, acclimation to cold temperatures, limiting ice formation, membrane lipid composition, HSPs, scavenging ROS, modulation of metabolism.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Books

Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P 2015 Molecular Biology of the cell 6e. Garland Science, Taylor and Francis Group, UK.

Buchanan BB, Gruissem W, Jones RL 2015 Biochemistry and Molecular Biology ofplants 2e. Wiley and American Society of Plant Physiologists, USA.

Cooper GM, Hausman RE 2007 The cell: A molecular approach 4e. Sinauer Associates Inc., USA.

Jones R, Ougham H, Thomas H, Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA.

Karp G 2016 Cell and Molecular Biology: Concepts and Experiments 8e. John Wiley & Sons, Inc., USA.

Kleinsmith LJ, Kish VM 1995 Principles of Cell and Molecular Biology 2e. HarperCollins College Publisher, USA.

Lewin B 2004 Genes VIII. Pearson Prentice Hall, USA.

Lodish H, Berk A, Zipursky SL, Matsudaira P, Baltimore, D, Darnell J2018Molecular Cell Biology 6e. W. H. Freeman and Company,USA.

Nelson DL, Cox MM 2021 Lehninger Principles of Biochemistry 8e. Macmillan, USA.

Taiz L, Zeiger E, Moller IM, Murphy A2015 Plant Physiology and Development 6e. Sinauer Associates, Inc., USA.

Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losic R 2009 Molecular Biology of the gene 5e. Pearson, India.

Review articles and Research papers

de Leon IP, Montesano M 2013 Activation of defense mechanisms against pathogens in mosses and flowering plants. I. J. of Molecular Sciences 14: 3178-3200. DoI: 10.3390/ijms14023178

Online resources

Guest D,Brown J, Plant defences against pathogens.

https://www.appsnet.org/Publications/Brown_Ogle/17%20Defence%20mechanisms%20(DIG&JFB).pdf

Freeman BC, Beattie GA 2008 An overview of plant defenses against pathogens and herbivores. The plant health Instructor. Iowa State University Digital Repository. DoI: 10.1094/PHI-I-2008-0226-01

Recent issues of the relevant 'Annual Reviews' should also be consulted

Semester II

Mandatory Lab 3 (MBO2L2): Plant physiology, Molecular biology, Plantbiotechnology, Plant breeding

Objectives

- To impart student the skills to prepare solutions, buffers etc. to carry out a scientific investigation.
- To instil the skills in the student to set-up the experiment and collect the data.
- To give hands-on experience to the student in molecular techniques and to handle basic equipment and apparatuses in the laboratory.
- To equip the student to evaluate the data and interpret the results.

Outcomes

- The student learns to prepare buffers, solutions and carries-out the experiment.
- The student is trained in routinely used molecular techniques.
- The student learns to handle the equipment in the laboratory.
- The student is able to present the data and interpret the results.

Plant physiology

1. To study the effect of time and enzyme concentration on the rate of reaction of enzyme (e.g., phosphatase, nitrate reductase etc.).
2. To study the effect of substrate concentration on the activity of an enzyme and determineits Km value.
3. To demonstrate the substrate-inducibility of the enzyme nitrate reductase.
4. To determine the activity, kinetics and sensitivity to inhibitors of the enzyme succinate dehydrogenase.
5. To prove Beer-Lambert's law using a suitable solution.
6. To extract chloroplast pigments from the leaves and prepare their absorption spectrum.
7. To isolate the intact chloroplasts and estimate choloroplast proteins by spot protein assay.
8. To prepare the standard curve of protein (BSA) and estimate the protein content in the given plant material by Lowry's or Bradford's method.
9. To determine the total carbohydrate content in the given sample.
10. To estimate the pectic substances in the given plant material by gravimetric method
11. To determine the chlorophyll a and cholorophyll b ratio in C3 and C4 plants.

12. To prepare the leaf protein concentrates from green vegetables.
13. To determine the reducing sugar content in the given sample by the Nelson-Somogyi method.
14. To study the effect of sodium azide on the respiration of germinating seeds by a suitable method.
15. To separate amino acids in the given plant material using thin layer chromatography.

Molecular Biology

1. To isolate the chloroplasts from the given plant tissue and demarcated the two subunits of RUBISCO by SDS-PAGE.
2. To perform the restriction digestion of the DNA.
3. To determine the size of the restricted fragments of DNA.
4. To detect the presence of the specific antigen by Dot ELISA method.
5. To map the genes in an organism from the given data. (at least 5 problems to be solved)
6. To separate the amino acids in the given sample by TLC method.
7. To separate the sugars in the given sample by TLC method.

Plant biotechnology and Plant breeding

1. To culture the *E. coli* using the streak plate technique.
2. To study the growth characteristics of *E. coli* using turbidimetric methods.
3. To isolate the plasmid from *E. coli* and quantify it with suitable method.
4. To perform restriction digestion of the given plasmid DNA.
5. To Clone the given DNA fragment in a plasmid vector.
6. To prepare competent cells from the given bacterial culture.
7. To transform the competent bacterial cells with the given vector and perform blue-white selection.
8. To prepare the media for plant tissue culture.
9. To surface sterilize the given seeds/explant for tissue cultural manipulation.
10. To isolate protoplast and determine its viability.
11. To fuse the protoplast using polyethylene glycol.
12. To work out the DNA sequence from the given autoradiogram and to identify the gene using online tools.
13. To search the literature data base of the given plant for the given information.
14. To search the sequence of the given gene in the Genebank.
15. To search the amino acid sequence of the given protein in the Genebank.
16. To emasculate and bag the given flower for crossing.
17. To hybridise the given flower using pollens from the appropriate donor plant.
18. To study the effect of mutagen treatment on the pollen fertility in the given crop.

Lab 3 (MBO2L2): Plant Physiology, Molecular biology, Plant biotechnology

Time: 6 hours Full marks: 100

Q. 1 To perform the given physiological experiment **A** and report the findings.	14
Q. 2 To perform the given Molecular biology experiment **B**.	14
Q. 3 To perform the given Plant biotechnology experiment **C**.	14
Q.4 Spotting: **D** (Physiology), **E** (Plant breeding), **F** (Molecular biology), **G** (Plant biotechnology).	8
Q. 5. Viva-voce.	25
Q. 6. Practical record.	25

Semester II

Mandatory Lab 4 (MBO2L3): Plant development & reproduction, Taxonomy, Ecology

Objectives

- To study the variation in structure of plant and its reproductive characters.
- To study the local flora by undertaking field tours.
- To learn the technique to describe and identify the plant.
- To undertake ecological investigations.

Outcomes

- The student studies the morphology, anatomy and embryology of the local plants.
- The student learns the biostatistical computations.
- The student is acquainted with the techniques and equipment to study the ecosystem andto describe & identify the plant.
- The student becomes familiar with the local flora and prepares the field report.

Plant development & reproduction

1) Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double – stained permanent slides of a suitable plant such as *Coleus, Kalanchoe, Tobacco* (*Nicotiana*).
2) Study of living shoot apices by dissections using aquatic plants such as *Hydrilla*.
3) Study of whole roots in monocots and dicots. Examination of L.S. of root from permanent preparation to understand the organization of root apical meristem (RAM) and its derivatives. Material to be used – Maize. Aerial roots (Proproots) of Banyan, *Pistia, Jussieua* etc.
4) Origin of lateral roots to be studied by taking L.S. of *Pisum, Cicer*. The study of root apex.As found in pteridophytes, gymnosperms, dicots and monocots.
5) Study of leguminous roots with different types of nodules.
6) Study of Primary meristem (Characters).
7) **Permanent tissues**: Parenchyma (Thin walled pith of sunflower, thick walled from pith of clematis, arenchyma from petiole of *Nymphaea*). Collenchyma (angular, lamellar); Sclerenchyma: Sclerenchyma fibres, sclereids (Brachysclerids from *Cocos*, macrosclerids from *Allium*, osteosclereids from seed coat of *Pisum*); Xylem: To observe in L.S.; Phloem:

Sievetube, companion cells; Secretory tissues: Digestive gland in *Drosera*, Nectaries in *Euphorbia pulcherima,* Resin ducts and oil ducts in *Pinus* (Schizogenous), Oil cavity in citrus fruit, Laticiferous ducts in *Vinca*; Hydathode (Water stomata) in *Tropaeolum,* tomato etc.

8) **Tissue systems:** Epidermal– Epidermis, Bulliform cells (leaf of *Trilicum*); *Stomata* – Structure, *Types* – *Ranunculus* or animocyclic – e.g., epidermal peel of clematis, anisocyclic, e.g., peel of *Brassica, Caryophyllaceous* or diacyclic – e.g., peel of dianthus, Rubiaceous– peel of Ixora, Graminaceous type – peel of grass leaf.

9) **Trichomes or Excrescence:** Sharp– Lantana, Looed– *Amaranthus*; Multicellular– tomato, *Helianthus*; Dendroid– *Mimosa*; Stellate– *Althea* or *Sida*.

10) **Ground tissue system**– Cortex, endodermis, pericyle.

11) Vascular tissue system:

i) Conjoint collateral open– e.g., Sunflower stem.

ii) Conjoint collateral closed– e.g., Maize stem.

iii) Bicollateral– *Cucurbita* stem.

iv) Concentric– Amphivasal– *Dracacena* stem, Amphicrible– *Pteris*.

v) Radial –Dicot or monocot root.

12) Stem anatomy

i) Primary structure– *Clematis, Helianthus, Cucurbita, Zea mays.*

ii) Secondary structure– *Moringa*.

iii) Anamalous Secondary growth

a. Adaptive anomaly: *Vitis, Aristolochia, Salvadora, Leptadaenia, Bignonia*

b. Non-adaptive anomaly: *Amaranthus, Boerhaavia, Chenopodium.*

iv) Secondary growth in Monocot stem: *Dracaena*.

13 Root anatomy: *Cicer, Pisum*, Maize, *Nymphaea.*

14 Leaf anatomy: Dorsiventral leaf- *Nerium*, Isobilateral leaf: *Zea mays*.

15 Study of microsporogenesis and gametogenesis by observing section of anther at different stages development study of microspore tetrad, study of mature pollen grains– *Crotalaria*.

16 Test for pollen viability, *in vitro* germination, pollen germination using hanging drop and sitting drop cultures.

17 Types of ovules, megasporogenesis, megagametogenesis study of monosporic, Disporic, and tetrasporic embryo sac by using permanent slides obturator, endothelium nucellus.

18 Mature dicot embryo, L.S. of maize grain showing, embryo, nuclear endosperm permanent slide. Cellular endosperm, isolation of embryo at different stages– globular, heart shaped, torpedo- shaped and mature embryo.

19 Study the polyembryony in *Citrus, Syzygium cumini* (Jamun).

Taxonomy

1. To study the plant life forms.
2. To study the root types and modification of roots.
3. To study the stem types and stem habit.
4. To study the stem branching pattern.
5. To study the Leaf– Leaf base, stipule, stipel, petiole, ligule, auricle, hastula, glochidium,

Lamina (shape, base, margin, marginal teeth apex surface, texture, trichomes, ptyxis, vernation duration, phyllotaxy, venation), Leaf type (simple and compound), modification, domatia and glands.

6. To study the Floral morphology– Thalamus, calyx, corolla, symmetry, androecium, adhesion and cohesion, gynoecium, number of carpels, style, stigma, ovary, placentation.
7. To study the Pollination– Self and cross: Contrivances, agents, special differentiation with pollinator attraction; Pollen structure its application in taxonomy– colpale, porate, exine ornamentation.
8. To prepare a cladogram on the basis of various morphological features of the species belonging to a genus.
9. To describe the plant specimens from representative, locally available families mentioned in the syllabus.
10. To describe a species based on specimens collected from various locations to study intra specific variation: Collective exercise.
11. To describe various species of a genus, location of key characters and preparation keys at generic level.
12. To describe various species of a family, location of key characters and preparation keys at family level.
13. To conduct field trips within and around the campus and compile the field notes and prepare herbarium sheets of the wild or cultivated plants collected during the visits.
14. To impart the skill of using floras and herbaria to identify the specimens described in the laboratory.
15. To demonstrate the utility of secondary metabolites in the taxonomy of some appropriate genera.
16. To compare different species of a genus and different genera of a family to calculate the similarity coefficients and preparation of dendrograms.

(One long and one short Botanical excursions are compulsory.)

Ecology

Biostatistics

1. To calculate the mean, variance, standard deviation and coefficient of variation from the given ecological data to compare the two means.
2. To calculate the mean and variance from the given ecological data and to use Student's t-test to compare the two means.
3. To find out the association between important grassland species from the given data usingchi square test.
4. To find out the relationship between two ecological variables using correlation analysis.
5. To perform the one-way ANOVA from the given data.

Ecological exercise

1. A trip to the grass land/forest/water body to get acquainted with the plant species.
2. To study the distribution pattern of the plant species by Quadrate/Transect/ Point centeredQuarter methods.

3. To determine the minimum size and number of quadrats required to study the grassland.
4. To study the qualitative parameters of distribution of plant species viz., Frequency, Density,Basal cover, dominance, Abundance and IVI.
5. To determine the diversity indices (Shanon-Weiner, species richness, B-diversity) from thegiven data.
6. To estimate the DO content in the eutrophic and oligotrophic water samples by azidemodification of Winklers method.
7. To determine the gross and net phytoplankton productivity by light and dark bottle method.
8. To estimate the chlorophyll content in SO2 fumigated and unfumigated leaves.
9. To analyse the soils of two different areas i.e., Cropland and forest/grassland for certainnutrients, CO3, NO3 etc.
10. To study the ecological adaptations of the given plants.

SEMESTER II

Lab 4 (MBO2L3): Plant development & reproduction, Taxonomy, Ecology

Time: 6 hours Full marks: 100

Q. 1 To perform the given exercise based on plant development **A**. 7

Q. 2 Write a note on given stage of micro- or megasporogenesis **B**. 3

Q. 3 To perform the given ecological exercise/solve the statistical problem **C**. 10

Q. 4 To describe the given plant **D** in technical language with floral formula and floral diagram. 11

Q. 5 To prepare the family/generic key **E**. 6

Q. 6 To identify species of the given plant **F** using Flora. 3

Q.7Spotting **G** (Plant development), **H** (Plant reproduction), **I** (Vegetative morphology), **J** (Floral morphology), **K** (Ecology) 10

Q.8Viva-voce. 25

Q.9 Practical record.

Programme outcomes
M. Sc. (Botany), Affiliated Colleges of University
Number of courses: 29

Targeted graduate attributes: Disciplinary knowledge, Critical thinking, Problem solving, Analytical reasoning, Communication skills, Teamwork,Moral and ethical awareness

	Programme outcomes
PSO1	The student is capable to demonstrate comprehensive knowledge and understanding of one or more branches of Botany, and ofcritical and clear thought about the plant world.
PSO2	The student develops the ability to analyse and contemplate on the various aspects of plants.
PSO3	The student is capable to undertake supervised research, identifying the problem, survey the literature, design & execute theexperiments, generate the data and draw conclusions.
PSO4	The student gets the hands-on experience in the routinely used laboratory techniques and equipment.
PSO5	The student develops the professional skills like identification of plants/algae/fungi, laboratory technician, scientific writing, dataanalysis, techniques in plant tissue culture, environmental impact assessment etc.
PSO6	The student is capable to write report and present the scientific data in form of figures, images and tables.
PSO7	The student is capable to undertake field tours for floristic, environmental and other exploratory surveys.
PSO8	A life-long inquisitiveness about plants and ways to put them at work for enhancing the quality of life is instilled in the student.
PSO9	The student is capable to derive benefits from the traditional knowledge of India.
PSO10	The student develops the qualities of a responsible global citizen and is able to work in a team.