GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

REVISED MINUTES

of the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

Saturday, 30th July, 2022

Time

10.00 a.m.

Council Hall
Goa University

	(Action: Assistant Registrar Academic – PG)
D 3.25	**Minutes of the Board of Studies in Data Science meeting held on 26.07.2022.** The Academic Council approved the minutes of the Board of Studies in Data Science meeting held on 26.07.2022 with the suggestion to revise/change the Course Codes for the Programme. **(Action: Assistant Registrar Academic – PG)**
D 3.26	**Minutes of the Board of Studies in Hindi meeting held on 10.05.2022 and 25.07.2022.** The Academic Council approved the minutes of the Board of Studies in Hindi meeting held on 10.05.2022 and 25.07.2022 with the following suggestions: 1. The Chairperson, Board of Studies was requested not to indicate the titles of the Courses in English language. 2. The Course Codes for the PG Programme to be revised/changed. 3. Semester wise the optional courses to be distributed. 4. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.27	**Minutes of the Board of Studies in Geography meeting held on 25.07.2022.** The Academic Council approved the minutes of the Board of Studies in Geography meeting held on 25.07.2022 with the following suggestions: 1. The Course Codes for the PG Programme to be revised/Changed. 2. DSCC-GEO 104: **Theory:** Environmental Geography to be replaced. 3. Courses to be shown Semester wise. 4. Separate Course Codes to be allotted to the Theory and Practical Courses. 5. Programme outcome and Course outcome to be added. 6. Lecture hours per week to be removed. 7. Number of Hours for each module to be clearly specified. 8. Date of implementation to be corrected to Academic Year 2022-23. 9. Suggested titles of the Courses to be checked. 10. The Board was requested to submit the syllabus as per format specified. 11. Typographical errors to be corrected. 12. The Chairperson, Board of Studies was requested to resubmit the syllabus incorporating the suggestions. The Vice-Chancellor was authorized to approve the same on behalf of the Academic Council. **(Action: Assistant Registrar Academic – PG)**
D 3.28	**Minutes of the Board of Studies in Botany meeting held on 27.07.2022.** The Academic Council approved the minutes of the Board of Studies in Botany meeting held on 27.07.2022 with the following suggestions: 1. The Course Codes for the PG Programme to be revised/changed. 2. Optional Courses to be indicated separately for each semester. 3. The Chairperson, Board of Studies was requested to resubmit the syllabus incorporating the suggestions. The Vice-Chancellor was authorized to approve the same on behalf of the Academic

	Council. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.29	**Minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022.** The Academic Council approved the minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022 with the following suggestions: 1. The Course Codes for the PG programme to be revised/Changed. 2. Minimum two optional courses to be offered. Four credits of optional courses shall be added in semester I and two credits in semester II. 3. Prerequisites for the Course to be added. 4. Course objectives to be included. 5. The Chairperson, Board of Studies was requested to resubmit the syllabus incorporating the suggestions and thereafter the Vice-Chancellor was authorized to approve the same on behalf of the Academic Council. 6. The proposed syllabus/Structure for M.Sc. Biotechnology and M.Sc. Marine Biotechnology of Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.30	**Minutes of the Board of Studies in Food Technology meeting held on 27.07.2022.** The Academic Council approved the minutes of the Board of Studies in Food Technology meeting held on 27.07.2022 with the following suggestions: 1. The word '&' used in the Course Code of the Programme to be removed/deleted. 2. The Course Codes for the Programme to be revised/Changed. 3. Programme structure to be changed. 4. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.31	**Minutes of the Board of Studies in Zoology meeting held on 26.07.2022.** The Academic Council approved the minutes of the Board of Studies in Zoology meeting held on 26.07.2022 with the following suggestions: 1. Number of credits for the course should be checked. 2. The Course codes and the Hours to be clearly mentioned/formatted. 3. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.32	**Minutes of the Board of Studies in PGDCG & MLT meeting held on 26.07.2022.** **(Item Withdrawn)** **(Action: Assistant Registrar Academic – PG)**
D 3.33	**Minutes of the Board of Studies in Marathi meeting held on 27.07.2022.** The Academic Council approved the minutes of the Board of Studies in Marathi meeting held on 27.07.2022 with the following suggestions: 1. The Chairperson, Board of Studies was requested not to indicate the titles of the

X AC- 9 (Special)
30.07.2022

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

F I N A L U P D A T E D A G E N D A

For the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

30th July, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administration Block

D 3.28 **Minutes of the Board of Studies in Botany meeting held on 27.07.2022.**

Part A

(i) Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level**: NA**

(ii) Recommendations regarding courses of study in the subject or group of subjects at the post-graduate level : **Revision of the Course Structure and syllabus of Semester I (Annexure I refer page no. 979) and Annexure II (refer page no. 1021)**

(a) Syllabus for following Discipline Specific Optional Courses were discussed and approved by BoS.

BODC-101: Plant Biotechnology : 3 Credits

BODC-102: Lab in Plant Biotechnology : 1 Credit

BODC-201: Modern Concepts in Plant Ecology: 3 Credits

BODC-202: Lab in Modern Concepts in Plant Ecology: 1 Credit

Part B

(i) Scheme of examinations at the under-graduate level: **Updated the model question paper marking scheme of paper BOC-109 Plant Molecular Biology and Genetic Engineering.**

(ii) Panel of examiners for different examinations at the under-graduate level: **Yes. Updated the master of panel of examiners for under-graduate level. (attached in sealed envelope)**

(iii) Scheme of examinations at the post-graduate level: **NA**

(iv) Panels of Examiners for different examinations at post-graduate level: **NA**

Part C

(i) Recommendations regarding preparation and publication of selection of reading material in any subject or group of subject or group of subjects and names of persons recommended for appointment to make the selection.: **NA**

Part D

(i) Recommendations regarding general academic requirements in the Departments of University or affiliated Colleges: NA

Part E

(i) Recommendations of text books for the courses of study at the under-graduate Level: **NA**

(ii) Recommendations of text books for the courses of study at Post-Graduate Level: **Yes. Updated the reference list.**

Part F

i. The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below**.**

	1. **Upgradation of M. Sc Botany Syllabus from 64 to 80 credits and increasing the contact hours from 12 to 15 hours per credit.** 2. **Introduction of TWO new Discipline Specific Optional Courses for M. Sc. Botany Semester I & Semester II.** 3. **Updated the Course Codes of M.Sc. Botany programme.** 4. **Updated the master panel of the examiners of UG Botany programme.** 5. **Updated the model question paper marking scheme of paper BOC-109 Molecular Biology and Genetic Engineering.** ii. The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself. Date: 27.07.2022 Sd/- Place: Goa University Signature of the Chairman **Part G**. The Remarks of the Dean of the Faculty i) The minutes are in order. ii) The minutes may be placed before the Academic Council with remarks if any. iii)May be recommended for approval of Academic Council. iv)Special remarks if any. Date: 27.07.2022 Sd/- Place Goa University Signature of the Dean **(Back to Index)**
D 3.29	**Minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022.** **Part A.** **i.** Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level**: N.A.** **ii.** Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **Reviewing the syllabus of M.Sc. Marine Biotechnology and M.Sc. Biotechnology for 80 credits.** **Part B** i. Scheme of Examinations at undergraduate level**: N.A.** ii. Panel of examiners for different examinations at the undergraduate level: **: N.A.** iii. Scheme of Examinations at postgraduate level: **: N.A.** iv. Panel of examiners for different examinations at post-graduate level: **N.A.** **Part C.** i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection**: N.A.** **Part D** i. Recommendation regarding general academic requirements in the Departments of University or affiliated colleges. **: N.A.**

D 3.28 Minutes of the Board of Studies in Botany meeting held on 27.07.2022.

Annexure I

School of Biological Sciences and Biotechnology
M.Sc. Botany Programme (Code: 1453)
(Choice Based Credit System - 80 Credits)

Course Structure

Course Code	Course Title	Credits
(CORE COURSES)		
Semester I		
BOCC-101	Algae, Bryophyta, Pteridophyta and Gymnosperms	3
BOCC-102	Lab in Algae, Bryophyta, Pteridophyta and Gymnosperms	1
BOCC-103	Systematics of Angiosperms	3
BOCC-104	Lab in Systematics of Angiosperms	1
BOCC-105	Internal Morphology and Developmental Biology of Angiosperms.	3
BOCC-106	Lab in Internal Morphology and Developmental Biology of Angiosperms	1
BOCC-107	Plant Physiology	3
BOCC-108	Lab in Plant Physiology	1
BODC-101	Plant Biotechnology	3
BODC-102	Lab in Plant Biotechnology	1
	Semester II	
BOCC-201	Microbiology and Plant Pathology	3
BOCC-202	Lab in Microbiology and Plant Pathology	1
BOCC-203	Cytogenetics and Plant Breeding	3
BOCC-204	Lab in Cytogenetics and Plant Breeding	1
BOCC-205	Plant Molecular Biology	3
BOCC-206	Plant Genetic Engineering	3
BOCC-207	Lab in Plant Molecular Biology and Genetic Engineering	2
BODC-201	Modern Concepts in Plant Ecology	3
BODC-202	Lab in Modern Concepts in Plant Ecology	1
Semester III		
Discipline Specific Generic Courses		
BOGC-301	Introduction to Omics	3
BOGC-302	Plant animal Interaction	4
BOGC-303	Ecotourism	2
BOGC-304	Lab in Ecotourism	2
BOGC-305	Mushroom biotechnology	1
Research Specific Optional Courses		
BORC-301	Research Methodology, Techniques and Instrumentation	4
BORC-302	Applied Phycology: Utilization and Management	3
BORC-303	Lab in Applied Phycology: Utilization and Management	1
Optional Courses		
BOOC-301	Bioinformatics	2
BOOC-302	Lab in Bioinformatics	1

BOOC-303	Mycorrhizal Biotechnology	2
BOOC-304	Lab in Mycorrhizal Biotechnology	1
BOOC-305	Seed Science and Technology	2
BOOC-306	Lab in Seed Science and technology	1
BOOC-307	Post-harvest Technology for Fruit Crops	2
BOOC-308	Plant Biochemistry	3
BOOC-309	Lab in Plant Biochemistry	1
BOOC-310	Oenology (Wine Science and Technology)	1
BOOC-311	Lab in Oenology (Wine Science and Technology)	1
BOOC-312	Marine Phytoplanktons	1
BOOC-313	Ethnobotany	2
BOOC-314	Introduction to Paleoflora	1
BOOC-315	Lab in Mushroom biotechnology	1
Semester IV		
BORC-401	Plant Histochemistry	3
BORC-402	Lab in Plant Histochemistry	1
BOSD	**Dissertation**	16

SWAYAM COURSES Recommended by BoS for the Post Graduate level		
Course Code	**Title of the Course**	**Credit Equivalent**
cec20-ge29	Academic writing	4
cec20-bt23	Biostatistics and Mathematical Biology	3
noc20-bt41	Nanotechnology in Agriculture	2
noc20-ag05	Organic Farming for Sustainable Agricultural Production	2
noc20-bt29	Biomedical Nanotechnology	1
cec20-ag14	Functional Food and Nutraceuticals	4
noc20-bt38	Wildlife Ecology	3
noc20-bt31	Experimental Biotechnology	3
cec20-bt24	Biomass Characterization	4

SEMESTER I

Discipline Specific Core Courses

Programme: M. Sc (Botany)
Course Code: BOCC-101
Title of the Course: Algae, Bryophyta, Pteridophyta and Gymnosperms.
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany.	

Objective(s):	To study general characteristics, classification, trends in classification, phylogeny and inter-relationships of Algae, Bryophyta, Pteridophyta and Gymnosperms.	
Content:	1. **Algae:** General introduction to algae including Cyanobacteria: Classification of Algae; Recent trends in the classification of Algae; General account of morphology, anatomy, reproduction, life histories, classification, phylogeny and inter-relationship, ecological and economic importance of the following groups: Chlorophyta, Charophyta, Chrysophyta, Cryptophyta, Pyrrhophyta, Phaeophyta and Rhodophyta. 2. **Bryophyta:** Introduction to Bryophyta: General characteristics, classification; Distribution, morphological, anatomical, reproductive studies and comparative account of sporophytes and gametophytes and interrelationships of the following groups: **Hepaticae:** Sphaerocarpales, Calobryales,Takkakiales, Marchantiales, Jungermanniales, **Anthoceotae**: Anthocerotales; **Musci:** Sphagnales, Andaeales, Polytrichales, Buxbaumiales Funariales including their fossil relatives. 3. **Pteridophyta:** General characters and classification of Pteridophytes; Comparative account of Psilophyta. Lycophyta, Eqisetophyta and Flicophyta; Aposory and Apogamy, Heterospory, Soral Evolution, Fossil Pteridophytes. 4. **Gymnosperms:** General characters and Classification of Gymnosperms; Comparative account of Morphology, anatomy, phylogeny and interrelationships of Pro- Gymnospermopsida, Gymnospermopsida, Gnetopsida and Fossil Gymnosperms.	**11 hours** **10 hours** **12 hours** **12 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study	
References/ Readings:	**Afroz Alam** (2015). Text Book of Bryophyta I. K. International Publishing House Private Ltd., New-Delhi. **Agashe, S.N.** (1995). Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. **Arnold, A.C.** (2005). An Introduction to Paleobotany, Agrobios (India), Jodhpur. **Bhatnagar S. P. and Moitra A.** (1996). Gymnosperms. New Age International, New Delhi. **Biswas C. and Johri B.M.** (1997). Gymnosperms. Narosa Publishers, New Delhi. **Bold H.C. and Wynne M.J.** (1985). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. **Cavers, F.** (1976). The inter relationships of the bryophyte. S.R. Technic, **Ashok Rajpath**, Patna. **Chapman V.J. and Chapman D.J.** (1975). The algae, 2nd Edition, Mac. Millan Publ. Inc. New York. **Chopra, R. N., and Kumar P. K.** (1988). Biology of Bryophytes. John Wiley and Sons, New York, NY. **Desikachary, T.V.** (1959). Cyanophyta ICAR, New Delhi	

Hoek, C. van den, Mann, D.G. and Jahns, H.M. (1995). Algae: An Introduction to Phycology, Cambridge University Press, UK.

Johri, **R.M., Lata, S. and Tyagi, K.** (2012). A Textbook of Bryophyta. Dominant Publishers &. Distributors Pvt., Ltd., New Delhi.

Kashyap, Shiv Ram (1929). Liverworts of The Western Himalayas and The Punjab Plain Part 1 Chronica Botanica, New Delhi.

Kashyap, Shiv Ram, (1932). Liverworts of the western Himalayas and the Punjab plain (illustrated): Part 2. The Chronica Botanica New Delhi.

Kramer, K.U. and Green, P.S. eds., (2013). Pteridophytes and Gymnosperms (Vol. 1). Springer Science & Business Media. Springer Berlin Heidelberg

Parihar, N.S. (1976). Biology and morphology of the Pteidophytes. Central Book Depot.

Parihar, N.S. (1980). Bryophytes: An introduction to Embryophyta Vol I Bryophyta. Central Book Depot.

Prem Puri (1981). Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi.

Prescott G. W. (1969). The algae: A review. Nelson, London.

Rashid, A. (1999). An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd., New Delhi.

Ramanujan, C.K.G. (1970). Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers.

Round, F.E. (1981). The Ecology of Algae, Cambridge University Press, Cambridge.

Sharma, O.P. (1990). Textbook of Pteridophyta. Macmillan India Ltd., Delhi.

Singh, V. P. (2006). Gymnosperms (Naked seed plants): Structure and Development, Sarup and Sons, New Delhi.

Sporne, K.R. (1965), Morphology of Gymnosperms Hutchinson University Library.

Sporne, K.R. (1986). The morphology of Pteridophytes. Hutchinson University Press, London,

Smith, G. M. (1995). The fresh water Algae of the United States, Mc-Graw Hill, New York.

Srinivasan, K. S. (1969). Phycologia India. Vol I & Vol II B.S.I., Calcutta.

Surange, K.R. (1966). Indian fossil Pteridophytes Council of Scientific and Industrial research. New Delhi.

Sundara Rajan, S. (1999). Introduction to Pteridophyta. New Age International Publishers, New Delhi.

Trainor, F.R. (1978). Introductory Phycology, Wiley & Sons. New York.

	Udar, R. (1976). Bryology in India: Chronica Botanica, New Delhi. **Udar, R.** (1970). Introduction Bryophyta Shashidhar Malaviya Prakashan, Lucknow. **Vashishta B.R.** (2015). Algae. S. Chand & Co., New Delhi. **Waston E.V.** (1971). Structure and life of Bryophytes. Hutchinson University Library, London.	
Learning Outcomes:	1. Students will have clear idea of the characteristics of the important plant groups taught in this paper. 2. Concepts in the evolution of plants will be clear to students.	

Programme: M. Sc (Botany)

Course Code: BOCC-102

Title of the Course: Lab in Algae, Bryophyta, Pteridophyta and Gymnosperms.

Number of Credits: 1 (30 hours)

Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective(s):	To introduce and expose the students to skills required in field and lab based on theory.	
Content:	1. Study of vegetative and reproductive features of important algal groups including Cyanobacteria with available representatives; Chlorophyta, Charophyta, Euglenophyta, Pyrrhophyta, Phaeophyta and Rhodophyta 2. Study of vegetative and reproductive features of important bryophyte groups with the available representatives- Hepaticae, Anthocerotae and Musci 3. Study of vegetative and reproductive features of important Pteridophytes with the available representatives: Psilotales, Lycopodiales, Selaginellales, Isoeteales, Equisetales, Ophioglossales, Marrattiales, Osmundales, Filicales, Marsileales and Salviniales. 4. Study of vegetative and reproductive features of important Gymnospermopsida and Gnetopsida with the available representatives.	**8 hours** **8 hours** **8 hours** **6 hours**
Pedagogy:	Conducting Practicals mostly with freshly collected and herbarium specimens, field visits, demonstrations, small projects, etc.	
References/ Readings:	**Bellinger, E. G., & Sigee, D. C.** (2015). Freshwater algae: identification, enumeration and use as bioindicators. John Wiley & Sons, UK. **Biswas C. and Johri B. M.** (1997). Gymnosperms. Narosa Publishers, New Delhi. **Bold H.C. and Wynne M. J.** (1985). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. **Desikachary, T.V.** (1959). Cyanophyta ICAR, New Delhi.	

	Parihar, N.S. (1976). Biology and morphology of the Pteidophytes Central Book Depot. **Parihar, N.S.** (1980). Bryophytes: An introduction to Embryophyta Vol I Bryophyta central Book Depot. **Prem Puri** (1981). Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi. **Prescott G.W**. (1969). The algae: A review. Nelson, London. **Rashid, A.** (1999). An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd. New Delhi. **Ramanujan, C.K.G.** (1970). Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers. **Sporne, K.R.** (1986). The morphology of Pteridophytes. Hutchinson University Press. London **Smith, G.M.** (1995). The fresh water Algae of the United States, Mc-Graw Hill, New York. **Srinivasan, K. S**. (1969). Phycologia India. Vol I & Vol II B.S.I. Calcutta. **Vashishta B.R.** (1988). Algae. S. Chand & Co., New Delhi. **Waston E.V**. (1971). Structure and life of Bryophytes 3rd Hutchinson University Library London.	
Learning Outcomes:	1. Able to understand technical description of plants and construct and use keys for identification, morphological, anatomical and reproductive characteristics of the respective plant groups. 2. Able to understand the concepts of the plant evolution. 3. Overall, they will have better understanding in area of plant diversity and will be able to carry out research work in this field.	

Programme: M. Sc (Botany)
Course Code: BOCC-103
Title of the Course: Systematics of Angiosperms.
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied Plant Taxonomy at undergraduate level. They should be good in basics of classification and nomenclature of angiosperms.	
Objective(s):	Taxonomy is fundamental to the rest of the studies in biology and at the same time it takes inputs from other branches. The ultimate aim of taxonomy is to understand the evolution at work. Angiosperms being the dominant as well as most evolved plant group, the sources of characters for taxonomy are also varied. It is also being practiced at various levels, from morphology to phylogenomics. This course aims to give comprehensive understanding in angiosperm taxonomy as well as its practice and applications.	

Content:	1. **Plant taxonomy**: Scope and importance; taxonomy as a synthetic discipline; principles and goals; applications - IUCN Red List, Conservation priorities;	**4 hours**
	2. **Floras, Revisions and Monographs:** Floras, Revisions and Monographs as basis of taxonomy; components, design and methods of floristics and revisionary/ monographic studies; role of herbaria, botanic gardens and literature in taxonomic studies; important literature resources.	**6 Hours**
	3. **Nomenclature:** Purpose, Principles, and overall knowledge of International Code of Nomenclature for algae, fungi, and plants (ICN) and Articles pertaining to typification, publication, priority, author citation and their application.	**7 hours**
	4. **Numerical methods in taxonomy:** Phenetics, Principal Component Analysis, Discriminant Analyses.	**4 hours**
	5. **Cladistics:** Introduction – advantages and problems; classical taxonomy as base for molecular systematics; systematics and phylogenetics classifications – use and utility. The choice of molecules in systematics – Nucleic acids, proteins and amino acids. Molecular evolution – neutral theory, molecular clock. Cladistics (Phylogeny) – concepts, parsimony, cladograms and trees; characters: apomorphic and plesiomorphic characters, homologous vs analogous; character states, binary and multistate characters, characters transformations; morphometric vs molecular characters. Trees - monophly, polyphyly and paraphyly; rooted and unrooted. Sequences – finding homologous sequences and alignment; local vs global alignment; pairwise and multiple sequence alignment. Tree construction – algorithmic (UPGMA and Neighbour Joining) and tree-searching (Parsimony, Maximum Likelihood and Bayesian). Phylogenomics as the modern trend in plant taxonomy.	**8 hours**
	6. **Phytogeography:** Basic terminologies and their understanding; Endemism- types and causes; vicariance; phytogeography and applications; phytogeographic regions of India and the world.	**5 hours**
	7. **Phylogeny and Classification of Angiosperms:** Fossil angiosperms and their ecology. Recent systems of classification; APG IV system of classification of angiosperms; characteristics and phylogeny of Basal angiosperms (Amborellales, Nymphaeales and Austrobaileyales); Order Ceratophyllales, Eudicots (order Ranunculales); Core eudicots [(Superrrosids (Rosids, Fabids, Malvids) and Superasterids (Asterids, Lamiids and Campanulids)].	**11 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study	
References/ Readings:	**APG IV** (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, Botanical Journal of the Linnean Society, Volume 181, Issue 1, 1 May 2016, Pages 1–20, https://doi.org/10.1111/boj.12385	

Barry G. Hall. (2011) (4th ed.). Phylogenetic Trees Made Easy: A How-To Manual. Sinauer Associates, Inc., Publishers, Sunderland, USA (Now Oxford University Press).

Besse, P. (2014). Guidelines for the choice of sequences for molecular plant taxonomy. In Molecular Plant Taxonomy (pp. 39-51). Humana Press, Totowa, NJ.

Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.

Ian J. Kitching, Peter L. Forey, Christopher J. Humphries and David M. Williams, (1998). Cladistics: The Theory and Practice of Parsimony analysis (2nd Ed.). The Oxford University Press.

Jain, S.K. and R.R. Rao. (1977). A handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi.

Joesph Felsenstein, (2003). Inferring Phylogenies. Sinauer Associates, Inc. (Now Oxford University Press).

Jones, S.B. and A.E. Luchsinger. (1987). Plant Systematics (2nd Ed.) McGraw Hill Book Company. New York.

Michael J. Moore, Pamela S. Soltis, Charles D. Bell, J. Gordon Burleigh and Douglas E. Soltis, (2010). Phylogenetic analysis of 83 plastid genes further resolves the early diversification of eudicots. (www.pnas.org/cgi/doi/10.1073/pnas.0907801107)

Michael George Simpson, (2010). Plant systematic (2nd Edition). Academic Press.

Nei, M. and S. Kumar, (2000). Molecular Evolution and Phylogenetics. Oxford University Press Inc.

Page, N. (2017). Photographic guide to endemic woody plants of western ghats. Trail Blazer Printers and Publishers

Peter Skelton and Andrew Smith, (2002). Cladistics: A Practical Primer on CD-ROM with accompanying booklet by Neale Monks. Cambridge University Press.

Quicke, D.L.J. (1993). Principles and Techniques of Contemporary Taxonomy. Blackie Academic & Professional (An imprint of Chapman & Hall.).

Robert W. Scotland and Toby Pennington, (2000). Homology and systematics: coding characters for phylogenetic analysis. Systematics Association.

Salemi, M. and A.-M. Vandamme, (2003). The Phylogenetic Handbook. A Practical Approach to DNA and Protein Phylogeny. Cambridge University Press.

Singh, G. (2010). Plant systematics: an integrated approach (Third Edition). CRC Press.

Singh, G. 2019. (4th ed.). Plant Systematics: Theory and Practice. Oxford & IBH Publishing Company Pvt. Limited.

	Sivarajan, V.V. (1991). (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford & IBH publishing Co. Pvt. Ltd. **Soltis, D., Soltis P., Endress, P., Chase M.W., Manchester S., Judd W., Majure L., and Mavrodiev, E.** (2017). Phylogeny and Evolution of Angiosperms (Revised and Updated edition). University of Chicago Press: 1427 E. 60th Street Chicago, IL 60637 USA. **Stevens, P. F.** (2001 onwards). Angiosperm Phylogeny Website. Version 14, July 2017 [and more or less continuously updated since]. http://www.mobot.org/MOBOT/research/APweb/ **Stuessy, Tod F.,** (2009). Plant taxonomy: the systematic evaluation of comparative data (2nd ed.). New York: Columbia University Press. **Takhtajan, A**. (Ed.). (2009). Flowering plants. Dordrecht: Springer Netherlands. **Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, Michael J. Donoghue,** (2015). Plant Systematics: A Phylogenetic Approach, Fourth Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA (Now Oxford University Press).	
Learning Outcomes:	1. Able to relate plant taxonomy to various other branches including conservation. 2. Should be in a position to understand and use Floras, Revisions and Monographs. 3. Should be able to apply nomenclatural rules. 4. Able to understand and interpret the phylogenetic trees. 5. Know the latest phylogenetic classification of angiosperms, relationships among major clades and their evolution.	

Programme: M. Sc (Botany)
Course Code: BOCC-104
Title of the Course: Lab in Systematics of Angiosperms
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied or have the practical knowledge of Plant morphological terms.	
Objective(s):	To learn plant taxonomy through dissection of flowers, use of Floras and field study and develop skills to handle plant identification and floristic work independently and at the same time able to handle molecular data for interpreting phylogeny.	

Content:	1. Writing of technical descriptions and demonstration of preparation of herbarium. 2. Construction of keys. 3. Identification of local species using Floras, keys and campus field trips. 4. Identification of 28 families using diagnostic characters; diagnostic characters to be illustrated. 5. Construction of phylogenetic tree based on gene sequences available at NCBI database (each student may be given different gene sequences/taxa). 6. A mini field project to study flora from Goa University campus based on Practical 3 and submission of report. ***Only 30 hours for any of the above practicals will be conducted depending on availability of plant material, equipments, etc.***	**4 hours** **2 hours** **8 hours** **14 hours** **4 hours**
Pedagogy:	Through actual dissection of floral parts/ Field trip /Practice	
References/ Readings:	**Barry G. Hall.** (2007). Phylogenetic Trees Made Easy: A How-To Manual, Third Edition. Sinauer Associates, Inc., Publishers, Sunderland, USA. **Jain, S.K. and R.R. Rao.** (1977). A handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi. **Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J.** (2007). Plant systematics: A phylogenetic approach. Third Edition. Sinauer Associates, Inc., Publishers, Sunderland, USA. **Lawrence, G.H.M.** (1951). Taxonomy of Vascular. Plants. Oxford & IBH Publishing Co. **Singh, G.** (2009). Plant systematics: an integrated approach. Science Pub Inc. **Utteridge, T. and G. Bramley.** (2014). Tropical Plant Families Identification Handbook. Kew Publishing.	
Learning Outcomes:	1. Able to write technical description of plants and construct and use keys for identification. 2. Able to identify common plant families based on the morphological features. 3. Able to recognize common plants. 4. Able to construct phylogenetic tree based on molecular sequences.	

Programme: M. Sc (Botany)
Course Code: BOCC-105
Title of the Course: Internal Morphology and Developmental Biology of Angiosperms.
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B.Sc. Botany. It is assumed that students have a basic knowledge of anatomy and developmental biology of higher plants.	
Objective(s):	The paper provides deeper understanding of various anatomical structures and their functions, several embryological processes including pollen pistil interaction, applied aspects of embryology, various palynological methods to understand pollen biology and pollen biotechnology of flowering plants.	
Content:	**Internal Morphology** 1. Meristems: Shoot and root apical and intercalary meristems; their ultra-structure and histochemistry; cytological and molecular analysis of the shoot apical meristem; autonomy of the meristem and vascular tissue differentiation in the shoot apex. 2. Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing. 3. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention. 4. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem. 5. Structural variability in leaves including leaf structures of C_3 and C_4 sub-types, CAM plants; leaf histogenesis; leaf meristems; evolution of leaf forms, heteroblasty. Origin, development and ultra-structure of trichomes and stomata. 6. Nodal anatomy: Nodal types, phylogenetic and evolutionary considerations. 7. Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny structure and functions. **Embryology** 1. **Microsporogenesis and formation of the male gametophyte:** Anther differentiation, pollen development and maturation, gene expression during pollen development, male sterility and pollen abortion, male gametogenesis. 2. **Megasporogenesis and formation of embryo sac:** Ovule differentiation and development, megasporogenesis, organization of embryo sac, types of embryo sac, gene function during megagametogenesis. 3. **Pollen pistil interaction and fertilization:** Pollen-stigma interaction and pollen tube guidance, pollen recognition by stigma, self-incompatibility, structural, biochemical and molecular aspects of gametophytic and sporophytic self-incompatibility. Double fertilization, *in vitro* fertilization. 4. **Endosperm and embryogenesis:** Endosperm, embryo, nutrition and growth of embryo. Gene action during embryogenesis, storage compounds in endosperm and embryo,	**4 hours** **2 hours** **4 hours** **2 hours** **5 hours** **2 hours** **4 hours** **2 hours** **2 hours** **4 hours** **4 hours**

	storage protein gene expression in transgenic systems; apomixis and polyembryony; applied aspects of embryology. **Palynology** 1. **Pollen Biology:** Pollen morphological characters, Pollen wall features, pollen development and evolution of pollen types, palynology and taxonomy. 2. **Aeropalynology:** Methods of aerospora survey and analysis; pollen allergy and pollen calendars. 3. **Mellittopalynology:** Honey bee and pollen loads; role of apiaries in crop production. 4. **Palaeopalynology:** Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations. 5. Pollen biotechnology for crop production and improvement.	**3 hours** **2 hours** **2 hours** **2 hours** **1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Self-Study	
References/ Readings:	**Batygina T.B.** (2009). Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. **Bhatnagar, S.P., P.K. Dantu and S.S Bhojwani**. (2018). The Embryology of Angiosperms, 6th Edition, Vikas Publishers House, New Delhi. **Bhojwani S. S. and Bhatnagar S. P.** (1992). The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi. **Esau K.** (1985). Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. **Fahn. A.** (1990). Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. **Hesse M. and Ehrendorfer F.** (1990). Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York. **Johri B.M.** (1984). Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. **Kashinath Bhattacharya, M. R. Majumdar and S. G. Bhattacharya.** (2006). A text Book of Palynology, New Central Book Agency (P) Ltd., Kolkata, India. **Lyndon R.F. (**1990). Plant Development, the Cellular Basis. Cambridge University Press, UK. **Maheshwari P.** (1985). An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi. **Metcalf C. R. and Chalk L.** (1950). Anatomy of Dicots Vol. I & II, London Press, Oxford. **Nair P.K.K.** (1985). Essentials of Palynology, Asha Publishing House, New York. **Raghavan V.** (2000). Developmental Biology of Flowering Plants, Springer-Verlag, New York.	

	Richard Crang, Robert Wise, and Sheila Lyons-Sobaski. (2018). Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, Springer. **Romberger J. A., Hejnowicz Z. and Hill J. F.** (1993). Plant Structure: Function and Development, Springer-Verlag. **Shivanna, K. R. and Rangaswamy N. S.** (1992). Pollen Biology- A Laboratory Manual, Narosa Publishing House, New Delhi. **Shivanna, K. R. and Sawhney V. K.** (1997). Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K.	
Learning Outcomes:	1. Being able to apply the knowledge of anatomy, structure and functions to all flowering plants. 2. Being able to apply the embryological processes and applied aspects of embryology in various situations. 3. Being able to apply the knowledge of pollen biology and biotechnology and methods and techniques learnt to various situations and applications.	

Programme: M. Sc (Botany)
Course Code: BOCC-106
Title of the Course: Lab in Internal Morphology and Developmental Biology of Angiosperms
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B.Sc. Botany. It is assumed that students have a basic knowledge of anatomy and developmental biology of higher plants.	
Objective:	To learn plant anatomy, embryology and palynology through sectioning and staining of various vegetative and reproductive parts of plants. Development of skills such as isolation of embryo and endosperm from early stages of seed development. Also, to study various ornamentation patterns in pollen grains from flowers and honey samples.	
Content:	1. Comparative anatomy of monocotyledon and dicotyledon root, stem and leaf. 2. Anatomical basis of identification C_3& C_4 sub types in grasses. 3. Phytoliths of grasses and their potential use in identification. 4. Anatomy of lenticels and periderm in plants. 5. Anatomy of monocotyledonous and dicotyledonous seeds. 6. Study of different types of stomata and trichomes. 7. Maceration of wood to study xylem components. 8. Study of microsporangium and microsporogenesis. 9. Study of megasporangium and embryo sac development. 10. Study of types of endosperm and its modifications. 11. Study of development of embryo in dicot and monocot. 12. Study of different ornamentation patterns in pollen grains by acetolysis method.	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**

	13. Analysis of honey samples to identify uni-floral or multi-floral honey. 14. Study the different components of phloem. ***Only 30 hours for any of the above practicals will be conducted depending on availability of plant material, chemicals, equipments, etc.***	**4 hours** **2 hours**
Pedagogy:	Hands on Practical.	
References/ Readings:	**Batygina T. B.** (2009). Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. **Bhattacharya K., M. R. Majumdar and S. G. Bhattacharya.** (2006). A text Book of Palynology, New Central Book Agency (P) Ltd., Kolkata, India. **Bhatnagar, S.P., P.K. Dantu and S.S Bhojwani**. (2018). The Embryology of Angiosperms, 6th Edition, Vikas Publishers House, New Delhi. **Bhojwani S. S. and Bhatnagar S. P.** (1992). The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi. **Esau K.** (1985). Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. **Fahn. A.** (1990). Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. **Hesse M. and Ehrendorfer F.** (1990). Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York. **Johri B.M.** (1984). Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. **Lyndon R. F.** (1990). Plant Development, the Cellular Basis. Cambridge University Press, UK. **Maheshwari P.** (1985). An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi. **Metcalf C. R. and Chalk L.** (1950). Anatomy of Dicots Vol. I & II, London Press, Oxford. **Nair P.K.K.** (1985). Essentials of Palynology, Asha Publishing House, New York. **Raghavan V.** (2000). Developmental Biology of Flowering Plants, Springer-Verlag, New York. **Romberger J. A., Hejnowicz Z. and Hill J.F.** (1993). Plant Structure: Function and Development, Springer-Verlag. **Crang R., Wise R., and Lyons-Sobaski S.** (2018). Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, Springer. **Shivanna, K. R. and Rangaswamy N. S.** (1992). Pollen Biology - A Laboratory Manual, Narosa Publishing House, New Delhi.	

	Shivanna, K. R. and Sawhney V. K. (1997). Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K.	
Learning Outcomes:	1. Being able to apply the knowledge of anatomy, structure and functions to all flowering plants. 2. Being able to apply the embryological techniques and methods to various plant species and situations. 3. Being able to apply the knowledge of pollen biology and methods and techniques to various plant species. 4. Environmental bio-monitoring of pollen allergens.	

Programme: M. Sc Botany
Course Code: BOCC-107
Title of the Course: Plant Physiology
No. of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of the subject at UG level.	
Objective(s):	This course teaches processes of plant water relationship, mineral nutrition and assimilation (nitrogen, sulphur and other inorganic nutrients), photosynthesis with emphasis on mechanism of abiotic stresses at physiological and molecular level with reference to crop productivity. The Course also teaches Plant growth and development due to light and phytohormones with emphasizes on cellular and molecular mechanism of signal transduction and physiological response.	
Content:	1. The physico-chemical organisation of the plant cell and cell organelles; structure and composition of plasma membrane fluid mosaic lipo-protein model, membrane, Water relation of plants, unique physico chemical properties of water; bulk movement of water and substances across the membrane, aquaporins, stomatal regulation of transpiration, anti transpirants. 2. Inorganic nutrition, macro and micro nutrients, deficiency symptoms, hydroponic studies; mineral absorption and translocation and assimilation; Nernst equation and Donnan's equilibrium. 3. **Nitrogen metabolism:** Nitrogen nutrition, organic nitrogen, nitrogen fixation in legumes, nitrate and ammonia assimilation: Sulfur metabolism and amino acid synthesis. Inter relationship between photosynthesis, respiration and nitrogen metabolism. 4. **Photosynthesis:** Importance of photosynthesis, Photosynthesis and environment. Light reaction: Radiant energy, photosynthetic apparatus, pigments and their biosynthesis; light harvesting complex; characteristics of two photosystems, photosynthetic electron transport, water oxidation and its molecular mechanism, photophosphorylation, pseudocyclic electron transport (Mehler reaction), Artificial photosynthesis. Climate change & food and fuel security.	**4 hours** **2 hours** **3 hours** **5 hours**

	5. **Dark reaction:** Carbon dioxide fixation in C3, C4 and CAM plants regulation of PCR cycle; photorespiration and its regulation, environmental factors affecting photosynthesis.	**3 hours**
	6. Aerobic and anaerobic respiration; cyanide independent respiration; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration. Chemo osmotic hypothesis.	**7 hours**
	7. **Reactive oxygen species:** ROS generation, its oxidative effect on biomoleculaes (protein, lipids and DNA) and enzymatic and non-enzymatic protective processes.	**3 hours**
	8. **Enzymes:** Structure and classification; mechanism of action; Michaelis-Menten equation; Lineweaver-Burk plot; enzyme regulation; allosteric enzymes, isozymes, co-enzymes and vitamins.	**2 hours**
	9. **Growth and development:** Phytochromes and light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting.	**2 hours**
	10. **Phytohormones:** Auxin; cytokinin; Gibberellins; ethylene; ABA. polyamines; brassinosteroids, jasmonate, their synthesis, distribution; and physiological effects. Molecular mechanism of action.	**5 hours**
	11. **Stress Physiology:** Abiotic stresses (drought, salt and metal), morphological and cellular adaptation; molecular mechanism of stress tolerance and protection.	**4 hours**
	12. Seed dormancy and germination, senescence, circadian rhythms in plants (with emphasis on exogenous factors and molecular mechanism).	**3 hours**
Pedagogy:	Lecture through PPT/E-learning/Assignments/Seminars/LSM Moodle.	
References/ Readings:	**Anderson *et al.*** (1996) Molecular Genetics of Photosynthesis, IRL Press, New Delhi. Hipkins, M.F and Baker N.R. Photosynthesis: Energy transduction a practical approach, IRL Press. **Blankenship R.E.** (2008) Molecular Mechanism of photosynthesis Blackwell Science, Oxford. **Bopp M.** (1985) Plant Growth substances. Springer, Berlin. **Buchanan B.B., Gruissen W. and Jones R.L.** (2nd Ed) (2015) Biochemistry and Molecular Biology of Plants, ASPP. **Coombs J., Hall D.O., Long, S.P. and Scurlock J.M.O**. (1985) Techniques in bioproductivity and Photosynthesis. Pergamon, Oxford. **Davies D.** (1980) The Biochemistry of Plants Academic Press. **Dennis D.T., Turnip D.H., Lefebvre, D.D. and Layzell D.B.** (1997) Plant Metabolism. Longman, Singapore. **Douce R.** (2002) Mitochondria in higher plants: Structure, function and Biogenesis. Academic Press. **Douce R and Day D.A.** (1985) Higher plant cell respiration. Springer, Berlin. **Davies P.J.** (1987) Plant Hormone and their role in plant growth development. Kluwer, Dordrecht, Netherland.	

Dixon R.O.D. and Wheeler C.T. (1986) Nitrogen fixation in plants. Chapman and Hall, New York.

Edwards G.E. and Walker D. (1992) C3-C4 mechanisms and cellular and environmental regulation of photosy nthesis. Univ. California Press.

Epstein E. (1972) Mineral nutrition of plants: Principles and perspectives. Wiley, New York.

Finkelstein A. (1988) Water movement through lipid bilayers, pores and plasma membranes: Theory and reality. Wiley, New York.

Friedman M.H. (2008) Principle and models of biological transport. Springer-Verlag. Stein W.D. Transport and diffusion across cell membrane. Academic press.

Hall D.O and Rao K.K. (1972) Photosynthesis Edwards-Arnold Ltd., UK.

Henry R.J. (1997). Plant Molecular Biology. Chapman and Hall, Panima, New Delhi.

Hopkins, W.G. (2008) Introduction to Plant Physiology, Wiley, New York.

Jarvis P.G. and Mansfield T.A. (1983) Stomatal Physiology, Cambridge. Kramer P.J. and Boyer J.S. Water relations of plants and soils. Academic Press. San Diego. Zimmermann M.H. Xylem structure and ascent of sap. Springer.

Karban R. and Baldwin I.T. (2007) Induced response to herbivory. Uni. Chicago press. Galston A. Life processes of Plants. Sci. Am. Library, New York.

Kendrick R.E. and Frankland B. (1976) Phytochrome and Plant Growth. Edward-Arnold, London.

Lauchli A. and Bieleski (1983) Inorganic plant Nutrition. Springer Brady N.C. The nature and properties of soils. Macmillan.

Levitt J. (1972) Response of plants to environmental stresses. Academic press, New York.

Luttuge U. (1997) Physiological Ecology of Tropical plants. Springer, Berlin.

Luttuge U and Higinbotham N. (1979) Transport in plants. Springer-Verlag, Germany Small J. pH and Plants, an introduction to beginners. Nostrand, New York.

Mann (1987) Secondary Plant Metabolites. Clarendon Press, Oxford.

Marschner H. (2011) Mineral nutrition of higher plants.

Mengel K. (1987) Principles of Plant Nutrition, Panima.

Mengel K. and Kirkby E.A. (1987) Principles of plant nutrition. Worblaufen-Bern, Switzerland.

Moore T.D. (1974) Plant Growth regulators. Kluwer, Dordrecht. The Netherland. Cherry J.H. Environmental Stress in plants. Springer, Berlin.

Mussel H. and Staples R.C. (1979) Stress physiology in crop plants. Wiley New York.

Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.

Nicholls D.G. and Ferguson S.J. (2013) Bioenergetics. Academic Press.

	Nobel Park S. (2009) Physicochemical and environmental Plant Physiology. Elsevier Science Publishing Co Inc. **Pollock C.J., Farrar J.F. and Gordon, A.J.** (1992) Carbon partitioning within and between organisms. BIOS Scientific, Oxford. **Salisbury, F.B. and Ross, C.W. (**1991) Plant physiology. (4th Ed), Wadsworth Publishing Company, Beverly. **Senger H.** (2012) Blue light effects in biological systems. Springer, Berlin. **Smith H.** (1980) Phytochrome and photomorphogenesis: An introduction to the photocontrol of plant development. McGraw Hill London. **Taiz, L., Zeiger, E., Moller I.M., and Murphy, A.** (2018) Plant Physiology and development. (6th Ed). Sinaeur Associates, Oxford University Press. **Thomson Tesar M.B.** (2015) Physiological basis of crop growth and development, Panima. **Wills R.** (2016) Post-harvest: An introduction to the physiology and handling of fruit. Nobel P.S. Physiological and environmental Plant Physiology. Allied Press. **Wray J. L. and Kinghorn J.R.** (1992) Molecular and genetic aspects of nitrate assimilation. Oxford Science, Oxford.	
Learning Outcomes:	Students will be able to demonstrate a depth of knowledge of physiological processes together with a better understanding of interaction and regulation of growth, metabolism and development and influence of environment on plant and further will be able to communicate scientific ideas in both written and oral forms to diverse audiences.	

(Back to Index) (Back to Agenda)

Programme: M. Sc Botany
Course Code: BOCC-108
Title of the Course: Lab in Plant Physiology
No. of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of the subject at UG level to be able to prepare various types of solutions, set pH, and handle basic laboratory tools and techniques.	
Objective(s):	This course is designed primarily to relate the learning of concepts in classroom to demonstrate experimental foundation of underline concepts/principles mainly on aspects of biological molecules, photosynthesis, respiration, transport, growth, growth substances and the stress physiological aspects of crop yield.	
Content:	1. Verification of law of diffusion and osmosis 2. Determination of water potential and osmotic potential and RWC in plant tissue. 3. Analysis of plant tissue for: Water, organic and inorganic content; Determination of a few macronutrients by Flame photometer, and micronutrient by AAS. 4. Quantitative estimation of protein.	**2 hours** **2 hours** **4 hours** **2 hours**

	5. Determination of ascorbic acid content of tissue. 6. Separation of protein by PAGE. 7. Pigments extraction, separation, identification and quantification. 8. Photo-oxidation of plant pigments. 9. Determination of oxidative damage in tissue using TBARS method 10. Enzyme activity with respect to temperature or pH or substrate concentration. 11. Isolation of intact organelles: chloroplasts and mitochondria. 12. Assay of photosynthetic electron transport activity from isolated chloroplast using oxygraph. 13. Assay of respiratory electron transport activity from isolated mitochondria using oxygraph. 14. Non-invasive measurements of photosynthesis (chlorophyll fluorometer). 15. Assay of nitrate/nitrite reductase activity in leaves/algae. 16. Estimation of Proline under stress and normal conditions. ***Only 30 hours for any of the above practicals will be conducted depending on availability of material, chemicals, equipments, etc.***	**2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Wet laboratory exercises	
References/ Readings:	1. **Mu, P., & Plummer D.T.** (2001). An introduction to practical Biochemistry. Tata McGraw Hill publishing company Limited. New Delhi. 2. **Harborne J.B.** (1984). Phytochemical Methods. Chapmann and Hall. London.	
Learning Outcomes:	1. The understanding of the rationale behind the practical procedures and ability to interpret the observations will enhance the student's ability to modify/design their own procedures if necessary as they advance to higher levels. 2. They will develop ability to apply the knowledge of plants symptoms/observation to their underline physiological causes.	

Discipline Specific Optional Courses

Programme: M. Sc (Botany)
Course Code: BODC-101
Title of the Course: Plant Biotechnology
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Biotechnology.	
Objective(s):	To impart recent knowledge in the field of Plant Biotechnology beneficial to economy and industry.	
Content:	1. **Plant Tissue Culture:** Totipotency; A brief history of plant tissue culture; Laboratory Organisation; Constituents of media,	**6 hours**

	Preparation of media, Selection of a suitable medium. Applications of Plant Tissue cultures.	
	2. **Cell Cultures:** Isolation of single cells, Bergmann's Plating Technique, Suspension cultures, types of suspension cultures, Synchronization of suspension cultures, Measurement of growth of cultures, Measurement of viability of cultured cells.	**4 hours**
	3. **Secondary Metabolites in Plant Culture**: Applications of secondary metabolites, Production of secondary metabolites, Selection of cell lines for high yield of secondary metabolites, Mass cultivation of plant cells, medium composition and effect of nutrients, Elicitor-induced production of secondary metabolites.	**5 hours**
	4. **Micropropagation:** Techniques of micropropagation, Multiplication by axillary buds, apical shoots and adventitious shoots, Factors affecting micropropagation, Applications and disadvantages of micropropagation.	**3 hours**
	5. **Somaclonal Variation:** History, Basis of somaclonal variations, Isolation of somaclonal variants, Factors affecting production of somaclonal variants, Applications and limitations of somaclonal variation.	**4 hours**
	6. **Germplasm Conservation and Cryopreservation:** Modes of conservation, Cryopreservation: Techniques of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology.	**4 hours**
	7. **Production of Haploid Plants:** *In vitro* and *in vivo* approaches, Androgenesis: Anther culture, Pollen culture, Development of androgenic haploids, Factors affecting androgenesis; Gynogenesis; Bulbosum method; Diploidization of haploid plants; Pollen as a tool in crop improvement, Pollen storage, Effect of radiation on pollen; Applications and limitations of haploids.	**8 hours**
	8. **Protoplast Culture and Somatic Hybridization:** Isolation of protoplasts: Mechanical and Enzymatic methods; Purification of protoplasts; Viability and plating density of protoplast; Culture of protoplasts; Regeneration of protoplasts; Sub protoplasts; Somatic hybridization: Fusion of protoplasts, Selection of hybrid cells, identification of hybrid (cells) plants, Chromosome number in somatic hybrids; Cytoplasmic hybrids or Cybrids; Genetic modification of protoplasts; Application and limitations of somatic hybridization.	**8 hours**
	9. **Introduction to gene transfer methods and transgenic plants:** Details of this topic is taught in **BOC-208** (Plant Genetic Engineering)	**1 hour**
	10. **Application of Biotechnology in Agriculture, Forestry and human welfare:** Marker assisted selection (MAS); Production of Biopesticides; Environmental and Enzyme biotechnology.	**2 hours**
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	

References/ Readings:	**Aguilar Cristobel Noe** (2008). Food Science and Food Biotechnology in Developing countries.Asiatech Publishers Inc. **Bhavneet Kaur, *et al.*** (2008). Current Topics in Biotechnology. M.D. Publications, New Delhi. **Bhojwani, S. S. and Razdan, M. K.** (1997). Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands. **Dubey, R. C.** (2009). A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi. **Gautam, H.** (2006). Agricultural & Industrial Applications of Bio-technology. Rajat Publication. **Harikumar, V.S.** (2006). Advances in Agricultural Biotechnology. Regency Publishers. **Kumar, H.D.** (2005). Agricultural Biotechnology. Daya Publishing House. **Park, S.** (2021). Plant Tissue Culture: Techniques and Experiments. Academic Press. **Prasad** (2008). Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. **Rajmohan Joshi** (2006). Agricultural Biotechnology. Gyan Books. **Vibha Dhawan** (2008). Biotechnology for Food and Nutritional Security. Teri Press.	
Learning Outcomes:	Able to work in Plant tissue culture laboratory, in Pharmaceutical and ayurvedic drug industries, research laboratories and plant germplasm banks.	

Programme: M. Sc (Botany)

Course Code: BODC-102

Title of the Course: Lab in Plant Biotechnology.

Number of Credits: 1 (30 hours)

Effective from AY: 2022-23

Prerequisites for the course:	Practical knowledge of Plant Biotechnology.	
Objective(s):	To train the students in practical aspects of plant biotechnology with special emphasis on somatic embryogenesis and organogenesis.	
Content:	1. Familiarizing with various physical and chemical sterilization techniques. 2. Preparation Murashige and Skoog (MS) Media. 3. Preparation of explants and inoculation. 4. Leaf and node culture. 5. Stem culture. 6. *In vitro* embryo culture of *Pisum sativum*. 7. Seed culture. 8. Anther culture using Datura flower. 9. Preparation of cell suspension cultures.	**2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**

	10. Study of cell viability methods. 11. Isolation of protoplast from plant leaves by enzymatic method. 12. Isolation of protoplast from plant leaf by mechanical method. 13. Study of protoplast viability. 14. Root organ culture (ROC) technique. 15. Preparation of synthetic seeds (alginate beads). ***Only 30 hours for any of the above practicals will be conducted depending on availability of material, chemicals, equipments, etc.***	**2 hours** **4 hours** **4 hours** **2 hours** **4 hours** **2 hours**
Pedagogy:	Laboratory Practicals.	
References/ Readings:	**Aguilar Cristobel Noe** (2008). Food Science and Food Biotechnology in Developing countries.Asiatech Publishers Inc. **Bhavneet Kaur, *et al.*** (2008). Current Topics in Biotechnology. M.D. Publications, New Delhi. **Bhojwani, S.S. and Razdan, M.K.** (1997). Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands. **Dubey, R.C.** (2009). A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi. **Gautam, H.** (2006). Agricultural & Industrial Applications of Bio-technology. Rajat Publication. **Harikumar, V.S.** (2006). Advances in Agricultural Biotechnology. Regency Publishers. **Kumar, H.D.** (2005). Agricultural Biotechnology. Daya Publishing House. **Rajmohan Joshi** (2006). Agricultural Biotechnology. Gyan Books. **Park, S.** (2021). Plant Tissue Culture: Techniques and Experiments. Academic Press. **Prasad** (2008). Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. **Vibha Dhawan** (2008). Biotechnology for Food and Nutritional Security. Teri Press.	
Learning Outcomes:	Able to work in Plant tissue culture laboratory, in Pharmaceutical and ayurvedic drug industries, research laboratories and plant germplasm banks.	

(Back to Index) (Back to Agenda)

SEMESTER II

Discipline Specific Core Courses

Programme: M. Sc (Botany)

Course Code: BOCC-201
Title of the Course: Microbiology and Plant Pathology
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of microbiology-bacteria, viruses, fungi and plant pathogens at UG level.	
Objective(s):	The aim of the course is to understand the interaction of microbes with plants and its relevance for agriculture and humans. In this, diversity of different microbes like bacteria, viruses and fungi will be studied. This paper will also focus on plant diseases with particular emphasis on identification of diseases and disease causative agents and fundamental concepts needed to manage crop diseases. In the plant pathology component, the course will also deal with genetics of host-pathogen interaction The objective is to make students understand beneficial and pathogenic microbes interacting with plants, the importance of their interaction in agriculture and to humans.	
Content:	1. **General Introduction:** Plant microbe interactions: Beneficial and Pathogenic health and diseases and the changing picture due to climate change. 2. **Plant Virology:** Origin of viruses, morphology, chemical composition (Viral nucleic acids, enzymes and proteins) and structure of virus, viral nomenclature; classification, introduction to molecular virology, viral databases and their use for understanding viral phylogeny, viral genomics and proteomics; classification and nomenclature of plant viruses; Genome organization and replication of viruses, isolation and purification of plant viruses, modern techniques to study the viruses; The virus cryptogram; Transmission of Plant Viruses, Viriods, Prions. 3. **Plant Bacterial Interactions and Mycoplasma:** Evolutionary aspects of plant microbe interaction; Species of bacteria associated with plants in health and disease; bacterial endophytes; phylloplane and rhizhosphere microbiology; role of bacteria in biogeochemical cycling; Present picture of phylogeny and systematics of bacteria; techniques used to study plant-microbe interactions; Agriculturally beneficial bacteria; Economic importance in relation to biological N-fixation, phosphate solubilization, siderophore production and production of antibiotics and enzymes, importance of Actinobacteria and actinorrhiza. Present knowledge of biology and role of Mycoplasma and L-forms. 4. **Mycological Dimensions of Plants:** Plants and fungi interaction through the window of evolution; Importance of mycology in Agriculture, History of mycology, Nomenclature, phylogeny and classification and fungal biodiversity, modern fungal systematics, morphology and molecular-based taxonomy; fungal plant ecology and fungal endophytes; general biology, forms, structure and functions of fungi; physiological aspects and nutritional modes of fungi; fungal genetics at classical and molecular level; the fungal holomorph; Reproduction: asexual	**2 hours** **5 hours** **5 hours** **7 hours**

	and sexual reproduction; Structural, functional and ecological specialization of fungal mycelia and spores; fungi in tropical habitats in relation to the plants. 5. **Study of different groups of fungi with suitable native examples:** Slime moulds, Chytridiomycota; Ooomycota; Glomeromycota; Zygomycota; Ascomycota and Basidiomycota. 6. **Economic and biotechnological dimension of fungi:** Study of economic importance of fungi; Endo- and ecto-mycorrhizae; Orchid mycorrhizae; Edible and poisonous mushrooms; Wood decay by fungi; Lichens; Yeasts; Fungal cultures; Fungal bioprospecting; Secondary metabolites; Industrial significance; Fungi in food processing, production of enzymes, alcohols, antibiotics; use of fungi for green chemistry and nanobiotechnological applications. 7. **Tropical Plant Pathology:** Diseases of plants in the tropics and their systematic studies using modern techniques. A brief history of plant pathology in India. Symptomatology in fungal, bacterial, viral and mycoplasma diseases of plants; Obligate and facultative pathogens. Classification of plant diseases; methods in the study of plant diseases; Koch postulates; Principles of infection and spread of disease; Sources of inoculum; Physiology of host-pathogen interaction; Role of enzymes and toxins in pathogenesis; Molecular basis of plant diseases; Susceptibility and resistance; Epidemiology, disease cycle, disease forecasting; Control of crop diseases by cultural, physical, chemical and biological methods; Crop rotation; Plant quarantine; Resistant varieties; Algal diseases. Diseases of cereals, pulses, vegetables, oil-seed crops, fruit plants, and plantation crops; Viruses, mycoplasma, protozoan and nematode diseases; Etiology, epidemiology and management of major diseases of paddy (blast, brown leaf-spot, sheath blight, bacterial leaf blight and tungro Virus), jowar (smut by *Sphacelotheca sorghi* and *S. cruenta*), sugarcane (red rot, smut, grassy shoot disease), groundnut (tikka), cotton (wilt), coconut (leaf blight, wilt, yellowing), banana (leaf spot, bunchytop), mango (powdery mildew, sooty mould). Post-harvest and market pathology; Remote sensing for analyzing plant diseases; Integrated pest management.	**10 hours** **8 hours** **8 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Moodle Based Work/Videos/Self-Study	
References/ Readings:	**Agrios, G.N.** (1997). Plant Pathology. Academic Press, New Delhi. **Ainsworth, G.C., Sparrow, F. K. and Sussman, A. S.** (1973). The Fungi. Academic Press, New York. **Alexopoulose, C.J., Mims, C.W., Blackwell, M.** (2007). Introductory Mycology. John Wiley & Sons, New York. **Atlas, M. and Bartha, R.** (2000). Microbial Ecology, Longmann, New York. **Bessy, E.A.** (2015) Morphology and Taxonomy of Fungi. Scientific publisher-Jodhpur. **Bilgrami, K.S. and Dube, H. C.** (1990). A text book of Modern Plant Pathology. Vikas Publishing House, New Delhi.	

Black, J. G. (1999). Microbiology–Principles and Explorations, Prentice Hall, London.

Brock, T. D. (1996). Biology of microorganisms Prentice Hall, London.

Burnett, J.H. (1968). Fundamentals of Mycology. Edward Arnold Ltd. London.

Butler, E.J. and Jones, S. G. (1949). Plant Pathology. Mc Millan, London.

Casida, L. E. (1997). Industrial microbiology. New Age Publishers, New Delhi.

Chatterjee, P.B. (1997). Plant Protection Techniques. Bharati Bhavan, Patna.

Chattopadhayay, S.B. (1991). Principles and Procedures of Plant Protection. Oxford & IBH, New Delhi.

Chopra, G.L. (1998). A text book of Fungi. S. Nagin & Co. Meerut.

Dube, H.C. (1996). An Introduction to Fungi. Vikas Publishing House, New Delhi.

Dubey, R. C. and Maheswari, D. K. (2010). A Text book of Microbiology, S. Chand & Company, New Delhi.

Elizabeth Moore-Landeeker (1996). Fundamentals of Fungi. Prentice Hall, New Jersey.

Hale, M.E. (1983). Biology of Lichens. Edward Arnold, London.

Harvey L., Arnold B., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell, J. (2008). Molecular Cell Biology 6th ed. W. H. Freeman & Co. New York.

Hudson, H. J. (1986). Fungal Biology. Edward Arnold, London.

Iwasa J. and Marshall W. (2020). 9th edition, Karp's Cell and Molecular biology-concepts and experiments. John Wiley & Sons, New York.

Kirk, P., Cannon, P., Minter, D., Stalpers, J. (2008) Ainsworth and Bisby's Dictionary of the Fungi, CABI Publishing.

Kumar, H. D. and Swati Kumar (1999). Modern concepts of Microbiology, Vikas Publishing House, New Delhi.

Manners, J.G. (1982). Principles of Plant Pathology. Cambridge University Press, London.

Marshall, H. (1999). Diseases of Plants. Anmol Publications Pvt. Ltd. New Delhi.

Mehrothra, R.S. and Aneja, K.R. (1990). An Introduction to Mycology. Wiley Eastern Ltd. New Delhi.

Mehrotra, R. S. (2000). Plant Pathology. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.

Mundkur, B.B. (1982). Text Book of Plant Diseases. Macmillan India Ltd., New Delhi.

Pathak, V.N., Khatri, N.K. and Pathak, M. (1996). Fundamentals of Plant Pathology. Agrobotanical Publishers (India), Bikaner.

Pelezar, M.J., Chan, E.C.S and Kreig, N.R. (2001). Microbiology-concepts and Applications. McGraw Hill, Inc. New York.

	Powar, C.B. and Daginawala, H.F. (1982). General Microbiology Vol.II. Himalaya Publishers, Bombay. **Rangaswamy, G. and Mahadevan, A.** (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi. **Rao, A.S.** (2001). Introduction to Microbiology. Prentice Hall of India, New Delhi. **Sharma, O.P.** (2007). Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi. **Sharma, P.D.** (2004). The Fungi for University students. Rastogi Publications, Meerut. **Sharma, P.D.** (2005). Plant Pathology. Narosa Publishing House, New Delhi. **Singh, R.S.** (2000). Introduction to the Principles of Plant Pathology. Oxford IBH, New Delhi. **Srivastava, J.P.** (1998). Introduction to Fungi. Central Book Depot, Allahabad. **Sumbali, G.** (2005). The Fungi. Narosa Publishing House, New Delhi. **Thind B. S.** (2019). Pathogenic Bacteria and Plant Diseases, CRC press.	
Learning Outcomes:	3. Be able to identify microbial habitats and plant disease symptoms. 4. Be able to work in a field laboratory for mycological studies. 5. Gain better understanding of tropical microbial biodiversity and their ecological roles. 6. Have better prospects as plant pathologist in various farms. 7. Will be able to understand molecular basis of plant pathogen interaction and disease.	

(Back to Index) (Back to Agenda)

Programme: M. Sc (Botany)
Course Code: BOCC-202
Title of the Course: Lab in Microbiology and Plant Pathology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of microbial habitats in a tropical setup and general idea of diseases affecting crops.	
Objective(s):	To impart requisite field and lab skills in plant microbiology and pathology with emphasis on tropical strains and local needs in agriculture and economy dealing with economically important microbes.	
Content:	**Microbiology** 1. Microbial ecology in relation to the plants-Introduction to field techniques to study plant-microbe interactions. 2. Isolation of Phylloplane microflora on microbiological media and visualization of colony characteristics. 3. Isolation of Rhizosphere microflora on microbiological media and visualization of colony characteristics.	**2 hours** **4 hours** **4 hours**

	4. Isolation of endophytes and visualization of colony characteristics.	**4 hours**
	5. Maintenance of pure cultures of phylloplane, Rhizosphere and endophytic microflora using common microbiological media.	**2 hours**
	6. Use of Microscopy in studying microbes in detail - preparation of unstained and stained specimens of eubacteria, actinobacteria. Photomicrography and digital image analysis of representative pure cultures and interpretation of results.	**2 hours**
	7. Preparation of unstained and stained specimens of yeasts, fungi. Examination of gram character of bacteria.	**2 hours**
	8. SEM study of bacteria, fungi, plant viruses using electron dense stains.	**2 hours**
	9. Studying Phylogeny of plant viruses using bioinformatics tools.	**2 hours**
	10. Study of root nodulation, symbiosome, *Rhizobium*, leghemoglobin and Quorum Sensing in bacterial population.	**2 hours**
	11. Methods of isolation and culturing of fungi: colony characters; microscopic observations; morphology of hyphae and spores.	**2 hours**
	12. Study of reproductive structures of different genera of fungi.	**2 hours**
	13. Study of fungal physiology in pure colonies – characterization of fungal colonies.	**2 hours**
	14. Microfluidics in mycology- fabrication and application of microfluidics devices to fungal cultures for real time visualization of fungal metabolic activities.	**2 hours**
	15. Introduction to mycological databases and myco-systematics on Internet.	**2 hours**
	16. Introduction to Mycobioinformatics- tools and techniques (exercise to construct fungal phylogenetic tree to be given).	**2 hours**
	17. Observation of different fungal substrates using sterile moist chamber incubation (e.g. herbivore dung; decomposing leaf-litter).	**2 hours**
	18. Observations on ecological succession of fungi; Terrestrial, marine and freshwater fungi.	**2 hours**
	19. Particle-plating technique for isolation of litter fungi.	**2 hours**
	20. Technique for isolation of fungal endophytes.	**2 hours**
	21. Isolation and serial dilution techniques (e.g. soil, dung and leaf litter).	**2 hours**
	Plant pathology	
	22. Collection of infected specimens in the field and observation of symptoms.	**2 hours**
	23. Hand sections and tease mounts from infected plant specimens.	**2 hours**
	24. Study of viral, bacterial and fungal diseases of crop plants (cereal, vegetable, fruit, and plantations) from surrounding habitats in Goa.	**4 hours**
	25. Submission of 10 dried herbarium specimens of infected plant materials [fungal (4) +bacterial (3) + viral (3)] collected from nearby habitats.	**2 hours**

	26. A mini field project to study crop diseases from field and market specimens. ***All plant pathology practicals will be conducted and any 16 hours from microbiology component will be conducted depending on availability of material, chemicals, equipments, etc.***	**4 hours**
Pedagogy:	Field visits and lab exercises/sample collections/use of electronic, digital and visual keys, herbarium production/videos/moodle guided exercises/mini projects/demonstration.	
References/ Readings:	**Agrios, G.N.** (1997). Plant Pathology. Academic Press, New Delhi. **Bilgrami, K.S. and Dube, H. C.** (1990). A text book of Modern Plant Pathology. Vikas Publishing House, New Delhi. **Butler, E.J. and Jones, S. G.** (1949). Plant Pathology. Mc Millan, London. **Chatterjee, P.B.** (1997). Plant Protection Techniques. Bharati Bhavan, Patna. **Chattopadhayay, S.B.** (1991). Principles and Procedures of Plant Protection. Oxford & IBH, New Delhi. **Sharma, P.D.** (2004). The Fungi for University students. Rastogi Publications, Meerut. **Srivastava, J.P.** (1998). Introduction to Fungi. Central Book Depot, Allahabad. **Sumbali, G.** (2005). The Fungi. Narosa Publishing House, New Delhi.	
Learning Outcomes:	1. Ability to work as a field microbiologist to sample various habitats and asplant pathologist being able to identify disease symptoms. 2. Being able to identify common micro and macrofungi from diverse natural habitats. 3. Being able to prepare herbarium of diseased plants. 4. Being able to isolate and manage microbial cultures. 5. Being able to perform image analysis of cultures. 6. Being able to apply techniques learnt in appropriate projects involving economically important microbes.	

Programme: M. Sc (Botany)
Course Code: BOCC-203
Title of the Course: Cytogenetics and Plant Breeding
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of Genetics and Plant Breeding.	
Objective(s):	The paper provides the students with detailed concepts of cytogenetic and Plant breeding.	

Content:	1. **Cell division (Mitosis and Meiosis):** Mitosis, Meiosis, Cytokinesis, Synaptonemal Complex (SC) and its significance in meiosis, Recombination nodules and their role in meiotic recombination, Mitotic poisons; Comparison between meiosis and mitosis.	**5 hours**
	2. **Genetic and Molecular basis of Cell division cycle:** Mitotic cell division; Meiotic cell division; Dynamics of chromosome movements during cell division; Cytokinesis, Astral microtubules and central spindle; Role of degradation of proteins (proteolysis in cell cycle.	**4 hours**
	3. **Chromosome theory of inheritance:** Association of paternal and maternal chromosomes at meiosis, Qualitative difference between chromosomes, Chromosome theory; Sex chromosomes and chromosome theory.	**2 hours**
	4. **The Nucleus and the Chromosome:** Nucleus; Nucleolus; Chromosome structure and organization: number, size and shape of chromosomes, Morphology, Karyotype, Euchromatin and Heterochromatin, Chemical composition, Ultrastructure, Organization within nucleus; Special type of chromosomes: Lampbrush and Salivary Gland Chromosomes, B-chromosomes; Prokaroytic nucleoids: Bacterial and Plasmid genome, Centromere and Telomere like structures in bacteria and plasmids.	**6 hours**
	5. **Extra chromosomal and Organellar Genetics:** Basis of extra chromosomal inheritance; Plastid inheritance; Shape, size of Chloroplast and Mitochondrial genomes, Replication of cpDNA and mtDNA.	**3 hours**
	6. **Plasmids, transposons and Retroelements:** Plasmids; Classification, Replication, transfer and recombination in plasmids, Plasmids as cloning vectors; Insertion sequence or IS elements; Transposons and controlling elements (in prokaryotes and Eukaryotes - copia, FB, P and I in Drosophila; Ty in yeast; AC-DC and Spm in corn; Retroelementsinvolving RNA phase: Retrotransposons in Plants; Mechanism of transposition; Uses of transposons.	**4 hours**
	7. **Molecular mechanisms to mutation and DNA repair**: Types of mutations; Molecular basis of mutations; mutagens, mechanism of DNA repair.	**4 hours**
	8. **Introduction to Plant Breeding:** Objectives and achievements; Pattern of evolution in crop plants; Plant introduction: Purpose of plant introduction, Achievements of plant introduction; Domestication and acclimatization.	**5 hours**
	9. **Heterosis and inbreeding depression:** Inbreeding depression; Effects of inbreeding; Degrees of inbreeding depression; Homozygous and Heterozygous balance; Heterosis in cross- and self-pollinated plants; Genetic basis of heterosis and inbreeding depression; Dominance hypothesis; Over-dominance hypothesis; Physiological basis of heterosis; Commercial applications.	**4 hours**
		4 hours

	10. **Distance hybridization and *in-vitro* techniques in plant breeding:** Distant hybrids and barriers in the production of distant hybrids, Application in crop improvement; Embryo, Meristem, Anther and Pollen culture, achievements. 11. **Genetics and crossing techniques of economically important crop plants:** Wheat, Rice, Maize and Cotton.	**4 hours**
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	
References/ Readings:	**Alberts, B. *et al.*** (2007) Molecular Biology of the Cell. 5th edition, Garland Science, Taylor & Francis. **Allard, R. W.** (1999) Principles of Plant Breeding. 2nd Edition. John Wiley, New York. **Broda, P. W.** (1979) Plasmids. Freeman, Oxford. **Darlington, C. D.** (1965) Cytology, Churchill. London. **De Robertis, E.D.P. and E.M.F. De Robertis** (1987) Cell and Molecular Biology. 8thedition. B. I. Waverly, New Delhi. **Gupta, P. K.** (2000). Cytology, Genetics and Evolution. 6th edition. Rastogi Publications, Meerut. **Lewin, B.** (2008) Genes IX. Oxford Univ. Press, New York. **Lodish, H. *et al.*** (2007) Molecular Cell Biology. 6th edition, W. H. Freeman, New York. **Poehlman, J. M. and D. Borthakur** (1969) Breeding Asian Field Crops. Oxford and IBH Publishing Co. New Delhi. **Sharma, J. R.** (1994) Principles and Practice of Plant Breeding. Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi. **Sinha, U and S. Sinha** (1989) Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt. Ltd. New Delhi. **Singh, B. D.** (2003) Plant Breeding – Principles and Methods. Kalyani Publishers, New Delhi. **Strickberger, M. W.** (1985). Genetics. 3rdedition. MacMillan Pub. Co., Philadelphia. **Swaminathan, M. S., et al.** (1983) Cytogenetics of crop plants. MacMillan India Pvt. Ltd., New Delhi. **Swanson, C. P. and P. L. Webster** (1989) The Cell. 7thedition Prentice-Hall of India Pvt. Ltd. New Delhi. **Watson, J. D. *et al.*,** (2009) Molecular Biology of the Gene. 6th edition. Benjamin Cummings, New York.	
Learning Outcomes:	1. The candidates can work in Research institutes like ICAR. 2. The candidates can start their own entrepreneurship in Tissue culture and breeding. 3. The candidates can work in Tissue culture laboratories.	

(Back to Index) (Back to Agenda)

Programme: M. Sc (Botany)
Course Code: BOCC-204
Title of the Course: Lab in Cytogenetics and Plant Breeding
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany with basic knowledge of Genetics and Plant Breeding.	

Objective(s):	To develop hands on training skills in Cytogenetics and Plant Breeding.	
Content:	1. Mitotic studies in suitable material: Squashing of the root tip and selection of metaphase plate. 2. Mitotic studies in suitable material*:* Camera Lucida drawing, Karyotype analysis, ideogram and derivation of karyotypic formula. 3. To study chromosomal aberrations in *Rheo sp.* 4. Meiosis in *Allium cepa.* 5. Induction of polyploidy in rice. 6. Observation of B chromosomes in suitable material –*Zea mays.* 7. Centre of origin of some economically important crop plants. 8. Floral biology of *Oryza sativa*. 9. Floral biology of *Zea mays.* 10. Effect of chemical mutagen (DES/HZ/EMS) on germination, growth and yield characteristics in *Oryza sativa*/*Brassica juncea /Impatiens balsamina.* 11. Crossing techniques in *Oryza sativa.* 12. Crossing techniques in *Zea mays.* 13. *In vitro* embryo culture of pea (*Pisum sativum*) ***Only 30 hours for any of the above practicals will be conducted depending on availability of material, chemicals, equipments, etc.***	**2 hours** **6 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **4 hours**
Pedagogy:	Laboratory practicals.	
References/ Readings:	**Alberts, B. *et al.*** (2007) Molecular Biology of the Cell. 5th edition, Garland Science, Taylor & Francis. **Allard, R.W.** (1999) Principles of Plant Breeding. 2nd edition. John Wiley, New York. **Broda, P.W.** (1979) Plasmids. Freeman. Oxford. **Darlington, C.D.** (1965) Cytology, Churchill. London. **De Robertis, E.D.P. and E.M.F. De Robertis** (1987) Cell and Molecular Biology. 8th edition. B. I. Waverly, New Delhi. **Gupta, P.K.** (2000). Cytology, Genetics and Evolution. 6th Edition. Rastogi Publications, Meerut. **Lodish, H. *et al.*** (2007) Molecular Cell Biology. 6th edition, W. H. Freeman, New York. **Lewin, B.** (2008) Genes IX. Oxford Univ. Press, New York. **Poehlman, J.M. and D. Borthakur** (1969) Breeding Asian Field Crops. Oxford and IBH Publishing Co. New Delhi. **Sharma, J.R.** (1994) Principles and Practice of Plant Breeding. Tata McGraw-Hill Publishing Co. Ltd., New Delhi. **Sinha, U and S. Sinha** (1989) Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt. Ltd. New Delhi. **Singh, B.D.** (2003) Plant Breeding – Principles and Methods. Kalyani Publishers, New Delhi. **Strickberger, M.W.** (1985). Genetics. 3rd edition. MacMillan Pub. Co., Philadelphia.	

	Swaminathan, M. S., *et al*. (1983) Cytogenetics of crop plants. MacMillan India Pvt. Ltd., New Delhi. **Swanson, C. P. and P. L. Webster** (1989) The Cell. 7th edition Prentice-Hall of India Pvt. Ltd. New Delhi. **Watson, J. D. *et al*.,** (2009) Molecular Biology of the Gene. 6th edition. Benjamin Cummings, New York.	
Learning Outcomes:	Upon completion of this course, the students will be able to take up job assignments in agri-based industries or work as research assistants on research projects.	

Programme: M. Sc (Botany)
Course Code: BOCC-205
Title of the Course: Plant Molecular Biology
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of biochemistry and molecular biology.	
Objective(s):	The paper deals with various molecular biological processes of DNA replication, transcription and translation. Molecular biology of recombination, synthesis and processing of various RNA molecules are discussed. Further the paper provides deeper understanding of regulation of gene expression in various organisms.	
Content:	**1. Introduction to Molecular Genetics and Genomics:** History of DNA molecule & discoveries till date. Physical nature of DNA: DNA is the genetic material, Chemical nature of DNA: Structure of nucleotides, Bonding, double helix and other helices. Factors affecting DNA structure. Organization of DNA. How Genes function at Molecular level - Replication, Transcription & Translation.	**5 hours**
	2. Molecular Biology of DNA Replication: Enzymes involved in replication, DNA replication is semi-conservative, Meselson-Stahl expt., Multiple Origins & bi-directional DNA replication in Eukaryotes, Replication of Virus & Theta replication of Circular DNA molecules, Rolling Circle replication, Plasmid DNA using a Rolling Circle, Unwinding, Stabilization & Stress relief, initiation by a Primosome complex, Chain elongation & Proofreading, discontinuous replication of the lagging strand, Terminator sequencing of DNA.	**8 hours**
	3. Molecular Biology of Recombination: Molecular mechanisms of Recombination, homologous and site-specific recombination, Gene conversion, Mismatch repair, the Holliday model of recombination, DNA damage and repair mechanisms: Single strand break & repair model.	**5 hours**
	4. Transcription: Enzymes in transcription; Basic features of transcription, Initiation, elongation and termination, RNA polymerases, promoters and enhancers; transcription activator	**7 hours**

	and repressor; transcription factors, prokaryotic and eukaryotic transcription.	**6 hours**
	5. Regulation of Gene Expression: Regulation of gene expression in prokaryotes and Eukaryotes. Transcriptional Control I, expression of lac operon, Transcriptional Control II, Attenuation, Antitermination, Methylation, Yeast GAL regulatory pathway, alteration of gene expression by DNA sequence rearrangements in *Salmonella* and*Trypanosoma*.	**7 hours**
	6. RNA Molecules and RNA Processing: Gene structure, Structure & Processing of messenger RNA, transfer RNA, ribosomal RNA, small interfering RNAs & micro RNAs, regulation through RNA processing & decay, alternative splicing, capping, polyadenylation, RNA transport, mRNA stability, co-suppression through RNA turnover, RNA interference (RNAi).	**7 hours**
	7. The Genetic Code and Translation: Molecular relation between Genotype & Phenotype, The Genetic Code, Factors involved in initiation, elongations and termination of translation, aminoacylation of tRNA, amino acyl tRNA synthetase, Post translational processing and modification, Transport of protein across the membrane.	
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Self-Study	
References/ Readings:	**Benjamin Lewin.** (2008). GENES IX. Jones and Bartlett Publishers, London, UK. **Tropp. B.E.** (2012). Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. **Brown T. A.** (2007). Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. **Coruzzi G.** (1994). Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London **Freifelder D.** (1990). Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. **Grierson D and S. Covey.** (1984). Plant Molecular Biology. Panima Educational Agency, New Delhi. **Henry R. J.** (2005). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. **Goldstein E.S., Krebbs J.E., Kilpatrick S.T.** (2011) Lewin's GENES X. Oxford University Press. **Old R.W. and Primerose S. B.** (1980) Principles of Gene Manipulation. An Introduction to Genetic Engineering. Blackwell Scientific Publishers. **Primrose, S. B. and R. M. Twyman.** (2009). Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. **Schuler M.A.Z., and Raymond E.Z.** (2005). Methods in Plant Molecular Biology. Academic Press, USA.	

	Shaw, C.H. (1988). Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC. **Tewari, K.K. and Singhal, G.S.** (1997). Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. **Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M & Losick R** (2008). Molecular Biology of Gene. Sixth Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. U.S.A.	
Learning Outcomes:	1. Being able to apply the knowledge of various molecular biological processes of DNA replication, transcription and translation to various other organisms. 2. Molecular biology of recombination, synthesis and processing of various RNA molecules could be employed in various situations and applications. 3. Being able to apply the regulation of gene expression to various other organisms.	

(Back to Index) (Back to Agenda)

Programme: M. Sc Botany
Course Code: BOCC-206
Title of the Course: Plant Genetic Engineering
No. of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of the subject at UG level. Knowledge of the subject at UG level. Also, knowledge of Plant tissue culture (regeneration methods).	
Objective(s):	This course is designed to understand basic principles, tools, techniques and recent advances in plant genetic engineering. Students will be exposed to restriction enzymes, vectors (plasmids, phasemids, etc.), joining and construction of genome and cDNA library and its screening for desired gene, transformation, etc. Student will also be exposed to site directed mutation techniques and other modern techniques such as sequencing, PCR, RT-PCR, RNAi etc.to study gene amplification and their expression. This paper also discusses other application of genetic engineering such as genetic marking and Molecular taxonomy.	
Content:	1. Introductory lecture on application of genetic engineering in the field of Plant science with regard to Agriculture, environment and medical field and study of plant taxonomy. 2. **Restriction and modification of DNA:** Basic principle of genetic engineering; restriction enzyme, cutting and joining the DNA; Vectors: plasmids, fine structure of vector gene desirability traits; construction of plasmid, purification of plasmids, various types of plasmids, bacteriophage and cosmid, single and double standard vectors and their growth cycle and regulation; various cloning strategies, Genome library and cDNA library, selection strategies for desired transformants, Genetic system provided by E. Coli and its host. 3. **Agrobacterium-mediated gene transfer:** Biology and molecular basis of Agrobacterium mediated plant	**2 hours** **8 hours** **6 hours**

	transformation and its application. Other direct gene transfer methods. Conventional Plant Breeding vs Genetic Engineering.	**3 hours**
	4. **Site directed mutagenesis:** DNA sequencing, various strategies for carrying out site directed mutagenesis.	**8 hours**
	5. **Structure, function and regulation of genome:** General organization and replication, transcription and translation of, mitochondrial and chloroplast genome; Genetic interactions in nucleus, chloroplast and mitochondria (retrograde signaling/plastid factors); Genetic codes in organelles.	**8 hours**
	6. **Gene silencing, editing, sequencing, amplification expression in plants:** Post transcriptional and transcriptional gene silencing (RNAi, Antisense), Gene editing and its application (CRISPER-CAS9), mutants of gene silencing, RNA virus in plants, virus induced gene silencing, Dideoxy and other methods of sequencing, PCR, RT-PCR and microarrays.	**7 hours**
	7. **Application of plant genetic engineering:** History of genetically engineered crop, Genetic engineering of plants for various desired characters (herbicide resistance, insect resistance, virus and abiotic stress resistance; to improvement of crop yield and quality; rice genome project, other sequenced genomes, Biotech crop (GM crops) and international development (With relation to matter discussed above).	
	8. **Genetic Engineering and public Concerns:** Ethical & Environmental concerns on Genetic Engineering of plants. Genetically Engineered Foods, Safety of Genetically Engineered Foods, Labeling, Future Foods and Regulatory Challenges, 'Pharm' Factories of the Future. Field testing of transgenic plants; Bio-safety issues in Indian contest; Indian rules, regulation and procedures for handling transgenic plants.	**3 hours**
Pedagogy:	Lectures/E-learning/Assignments/Seminar/Moodle/Group discussion	
References/ Readings:	**Armstrong CL, Spencer TM, Stephens MA and Brown SM** (2000). Transgenic maize. In: O'Brien L, Henry RJ (eds.), Transgenic cereals. American Association of Cereal Chemists, St. Paul, Minnesota, USA. **Coruzzi G.** (1994). Plant Molecular Biology-Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. **David Freifelder.** (1987). Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. **Grierson D and S. Covey.** 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi. **Grumezescu, A.M., & Holban, A.M.** (Eds.). (2017). Genetically Engineered Foods (Vol. 6). Academic Press. **Isaacson, W.** (2022). The Code Breaker--Young Readers Edition: Jennifer Doudna and the Race to Understand Our Genetic Code. Simon and Schuster. **Lynas, M.** (2018). Seeds of science: why we got it so wrong on GMOs (Vol. 34). Bloomsbury Publishing. **Lewin Benjamin**. (1999). GENES VII. Oxford University Press.	

	Old, R.W., and Primerose S. B. (1980) Principles of Gene Manipulation. An Introduction to Genetic Engineering. Blackwell Scientific Publications. **Pahara J.**, & **Legault J**. (2021) 2nd Edition Zero to Genetic Engineering Hero. Make community. **Patrick Faraday**. (2018) Genetic Engineering, Emerging concepts and Technology, Syrawood Publishing House. **Shaw, C. H.** (1988). Plant Molecular Biology-Practical Approach. IRL Press, Oxford, Washington DC. **Tewari, K. K. and G. S. Singhal.** (1997). Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. ***Books referred for BOC-207 (Plant Molecular Biology) should also be read.***	
Learning Outcomes:	After completing this course student should be able to understand basic principles of plant genetic engineering in order to develop and validate transgenic plants.	

Programme: M. Sc (Botany)
Course Code: BOCC-207
Title of the Course: Lab in Plant Molecular Biology and Genetic Engineering
Number of Credits: 2 (60 hours)
Effective from AY: 2022-2023

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of biochemistry, molecular biology and instrumental techniques at UG level.	
Objective(s):	To learn and understand various methods, techniques and hands on experiments with techniques concerning study of plant molecular biology and genetic engineering. This course is designed to introduce students to both the principles and the applications of molecular recombinant DNA technology to plants and microbial organisms. It describes the use of genetically engineered products to solve agriculture and environmental problems for human welfare.	
Content:	1. Preparation of media and other requirements, sterilized glassware etc. 2. Isolation and purification of genomic DNA from plant materials. 3. Isolation and purification of RNA from plants. 4. Culture of plasmid and maintenance of culture. 5. Isolation of plasmid DNA. 6. Quantitative estimation of genomic DNA and RNA using spectrophotometer. 7. Agarose gel electrophoresis of genomic DNA and RNA and detection using gel documentation system. 8. Digestions of DNA by restriction enzymes and size fractionation of fragments. 9. Ligation of digested fragments. 10. Primer designing. 11. cDNA formation using reverse transcriptase. 12. RT-PCR quantitation of selected gene(s) using SYBRG.	**2 hours** **4 hours** **4 hours** **2 hours** **4 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours**

	13. Use of software for quantitation of gene and compare the expression level. **4 hours** 14. Southern Blotting/Northern Blotting/Western Blotting (any one) **8 hours** 15. Creating a transformant using commercial construct. **2 hours** 16. 16 or 18s rRNA analysis. **4 hours** 17. Leaf disc transformation using Agrobacterium, establishment of transgenic plants and GUS staining of GFP viewing. **4 hours** 18. Amplification of genomic DNA using ISSR/ RAPD random primers in PCR and agarose gel electrophoresis and detect the banding patterns under gel documentation system and analysis of bands to understand genetic variation in plants. **4 hours** ***Only 60 hours for any of the above practicals will be conducted depending on availability of material, chemicals, equipments, etc.*** **4 hours**
Pedagogy:	Hands on practicals.	
References/ Readings:	**Brown T. A**. (2007). Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. **Burton E. Tropp.** (2012). Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. **David Freifelder.** (1990). Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. **Dodds J.H.** (1985) Plant Genetic Engineering. Cambridge University Press. **Gloria Coruzzi.** (1994). Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. **Grierson D & S. Covey.** (1984). Plant Molecular Biology. Panima Educational Agency, New Delhi. **Henry R. J.** (2005). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. **Kurnaz I.A.** (2015) Techniques in Genetic Engineering. CRC Press. **James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine and Richard Losick. (**2008). Molecular Biology of Gene. Sixth M.Sc Syllabus - 2018 Core 29 Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. U.S.A. **Lewin Benjamin.** (2008). GENES IX. Jones and Bartlett Publishers, London, UK. **Mary A. Schuler and Raymond E. Zielinski**. (2005). Methods in Plant Molecular Biology. Academic Press, USA. **Neal Stewart J.C.** (2008) Plant Biotech and genetics: Principle, techniques and applications. Wikley jones and Sons, Canada **Primrose, S. B. & R. M. Twyman.** (2009). Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. **Shaw, C.H.** (1988). Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC.	

	Tewari, K.K. & G.S. Singhal. (1997). Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. **Vennison, D.C.S.** (2009). Laboratory manual for genetic engineering. PHI Learning Pvt. Ltd..	
Learning Outcomes:	After completing this course student should be able to recognize the foundations of modern biotechnology and explain the principles that form the basis for recombinant DNA technology and be able to carry out R & D work or work in quality control laboratory on molecular biology and recombinant DNA technologies such as vector construction, cloning and gene expression etc.	

Discipline Specific Optional Courses

Programme: M. Sc (Botany)
Course Code: BODC-201
Title of the Course: Modern concepts in Plant Ecology.
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of basic ecology at undergraduate level.	
Objective(s):	This course is designed to introduce the concepts and principles of plant and environmental ecology, conservation, sustainable development, population characteristics, community dynamics, ecosystem structure &functions and application of these concepts to solve environmental problems. It seeks to equip students with a comprehensive set of subject-specific knowledge and skills pertaining to ecology.	
Content:	1. **Population Ecology**: Life History Diversity; Environmental characteristics and plant life histories; Life history traits and trade off; population variability, distribution and limiting factors; population growth and regulation; survivorship curve types; population dynamics - density dependent and density independent factors, logistic and exponential growth. Frequency, Density, Abundance; diversity indices, Simpson's diversity index, Shannon's Wiener diversity index. 2. **Spatial Ecology:** Metapopulations, Levins metapopulation model; habitat fragmentation and extinction; metapopulation model and conservation biology; metapopulation dynamics; competition and co-existence. Metacommunities in heterogenous environment-perspectives with special reference to neutral perspectives; species co-existence: fluctuation dependent mechanisms--the storage effect, the intermediate disturbance hypothesis (IDH); niche-based and neutral processes in communities. Environmental (ecological) Niche modelling: Fundamentals of Environmental Niche Modelling (ENM)/Species Distribution Modelling (SDM); Application of ENM in ecology and conservation.	**6 Hours** **12 Hours** **7 Hours**

	3. **Ecological interactions:** Native, Introduced, Exotic and invasive species, introduction and causes. Predator-Prey: Predator functional responses; Lotka-Volterra model; Rosenzweig-MacArthur model; predator preference and Optimal Foraging Theory; Non-consumptive effects of predators; consumer-resource models of competition; competition for multiples resources; beneficial interactions in communities; species interactions in ecological networks; keystone species; body size and foraging relationships.	**7 Hours**
	4. **Molecular and Evolutionary Ecology:** Rapid evolution and ecological consequences; community phylogenetics; phylogenetic niche conservation; Molecular Ecology-Genetic diversity in natural populations, population structure, genetics of metapopulations, gene flow and migration rates, identification of immigrants, genetic estimation of effective population size, population bottlenecks; genomics in adaptive radiation; phylogeography-genetic variation in space and time, applied phylogeography; conservation genetics; molecular ecology and Genetically modified organisms (GMOs).	**4 Hours**
	5. **Applied Ecology and conservation biology:** Global environmental change; UNSDG, IPCC, COP-25, Kyoto protocol, Carbon test plants and carbon sequestration; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches; Principles of conservation and overview of conservation efforts; major approaches to management; Indian case studies on conservation/management strategy; Assessing Impacts and Vulnerabilities; Global Policy on Climate and Adaptation.	**4 Hours**
	6. **Ecological economics (EE), Environmental valuation and auditing (EA):** Basics of EE, Polluter pays principle; Gross national and gross natural products; Natural resources accounting procedure (NRA); Techniques used in NRA; Evaluation of ecosystem services; Fundamentals of bio-economics; Importance of EE in National Planning and Development.	**5 Hours**
	7. **Environmental Impact Assessment (EIA):** History of EIA, EIS, EMP; EIA laws and regulations; projects requiring EIA in India; EIA methodology-Checklist, overlay, modeling, network, matrix, computer assisted, EIA software packages and tools; Biological Impact assessment; preparing EIA reports, public hearing procedures; EIA case studies from India; Study of EIA manuals.	
Pedagogy:	Lectures/ Tutorials/Assignments/ Mini Projects/Use of software tools and online websites/Moodle based Exercises/ Videos/ Demonstrations/ Field visits/Self-study/Expert Lectures/Training workshops.	
References/ Readings:	**Alan, B.** (1993). Applying Ecology. Chapman & Hall **Beebee, T.J.C. and Graham, R.** (2004). An Introduction to Molecular Ecology. Oxford University Press.	

	Begon, M., Townsend, C. R. and Harper, J. L. (2005). Ecology: From individuals to Ecosystems 4th edition, Wiley-Blackwell. **Cain, Michael L., Bowman, William D and Hacker, Sally D** (2008). Ecology. Sinauer Associates, Inc. **Canter L** (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company. **Freeland, J.R., Heather, K. and Petersen, S.** (2011). Molecular Ecology (Second Edition). John Wiley & Sons, Ltd. **Graham R., Michael, S. and Trevor, B.** (2017). An Introduction to Molecular Ecology (Third Edition). Oxford University Press. **Jain, S. V.** (2021). Applied Ecology and Sustainable Environment. BFC Publications. **Michael, B., Martin, M. and Thompson, D.J.** (2009). Population Ecology- A unified study of Animals and Plants. Blackwell Science. **Mittelbach, G.G.** (2012). Community Ecology. Sinauer Associates, Inc. **Nunes, P. A., Van Den Bergh, J. C., & Nijkamp, P.** (2003). The ecological economics of biodiversity: methods and policy applications. Edward Elgar Publishing Ltd. **Odum, E. P.** (2007) Fundamentals of Ecology, 5th edition, Thomson books. **Prasad, K. V.** (2022) 'Ecosystem Ecology'. In Insect Ecology: Concepts to Management, Springer, Singapore, 2022. **Yadav, P. R., and Mishra, S. R.** (2004) Environmental biology, Discovery publication, New Delhi.	
Learning Outcomes:	1. Able to predict different ecological models and state its applications in ecology and conservation. 2. Should be able to describe ecological interactions; environmental factors governing these ecosystems and explain the factors leading to environmental degradation, their reasons and impacts on the environment. 3. Apply management strategies and methods to conserve diversity at all levels, from genes to landscapes.	

Programme: M. Sc (Botany)

Course Code: BODC-202

Title of the Course: Lab in Modern Concepts in Plant Ecology

Number of Credits: 1 (30 hours)

Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of field work, sampling and have knowledge of Plant ecological terms.	
Objective(s):	To impart knowledge about field, lab, and IT-based ecological techniques and to provide them the tools they need to independently examine any environmental problem and, where possible, come up with suitable solutions in a substantial way.	

Content:	1. Study of ecotones and edges in natural ecosystems.	**2 Hours**
	2. Study of local landscapes using maps/satellite images/modelling tools.	**2 Hours**
	3. Study of stratification and physiognomy.	**2 Hours**
	4. Study of vegetation by sampling methods (Transect/Bisect/Trisect/Ring counts/Quadrat method).	**2 Hours**
	5. To assess the trophic status of aquatic habitat through algal count method.	**2 Hours**
	6. Effect of abundance of single species populations on community in aquatic ecosystem.	**4 Hours**
	7. Phytogeographic analysis preferably using BEAST software.	**2 Hours**
	8. Community phylogenetics.	**2 Hours**
	9. Analysis of MODIS products for global vegetation phenology and productivity.	**2 Hours**
	10. Use of MAXENT modeler for predicting species distributions.	**2 Hours**
	11. Quantitative character analysis of plant communities using the random sampling method (Abundance, density, frequency, basal cover, canopy cover, etc.); Simpson's diversity index, Shannon's Wiener diversity index. Quantitative character analysis using the belt transect and line transect methods; and biological spectrum analysis.	**2 Hours**
	12. Study of effect of effluents on growth of plants.	
	13. To study indices of similarity & dissimilarity in a community.	**4 Hours**
	14. Analysis of plant communities through qualitative and remote sensing methods, Statistical tools and softwares.	**2 Hours** **2 Hours**
	15. Performing Rapid EIA using Leopold interaction matrix (different projects).	**2 Hours**
	16. Community composition of plankton community.	
	17. Effect of zooplankton grazing on phytoplankton communities.	**4 Hours**
	18. Pool size v/s Diversity of aquatic plants.	**2 Hours**
	19. Study of density of single species on growth rate.	**2 Hours**
	20. Assessing the gene flow among populations using molecular markers.	**2 Hours** **2 Hours**
	21. Estimation of effective population sizes from data on genetic markers.	**2 Hours**
	22. Survey of key stone species.	
	23. Study of technical reports on Solid waste Management.	**2 Hours**
	24. Performing rapid biological impact analysis.	**2 Hours**
	25. Software for EIA-solid waste management.	**2 Hours**
	26. Field visit – data collection and report preparation.	**2 Hours**
	27. Biodiversity assessment of forest tree community.	**2 Hours**
	28. Assessment of forest disturbance for conservation aspects.	**2 Hours** **2 Hours**

	Only 30 hours for any of the above practicals will be conducted depending on availability of plant material, chemicals, equipments, etc.	
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Self-study/Videos/Expert Lectures/Group Discussion/Mini Projects/Workshops	
References/ Readings:	**Cavender-Bares, J., Gamon, J.A., & Townsend, P.A.** (2020). Remote sensing of plant biodiversity. Springer Nature. **Curtis, J. T.** (1956). Plant ecology workbook. A laboratory, field and reference manual. Plant ecology workbook. A laboratory, field and reference manual. **Erickson, P. A.** (1994). A practical guide to environmental impact assessment. Academic Press Inc. **McLean, R. C., & Ivimey Cook, W. R.** (1946). Practical field ecology. Practical field ecology. **Pommerening, A., & Grabarnik, P.** (2019). Individual-based methods in forest ecology and management (Vol. 411). Cham: Springer. **Prach, K., & Walker, L. R.** (2020). Comparative plant succession among terrestrial biomes of the World. Cambridge University Press.	
Learning Outcomes:	2. Will be familiar with modern tools and approaches and will be able to apply them properly for research 3. Be aware of the suitable use of field techniques, data gathering, mapping, analysis and interpretation. 4. Able to take up interdisciplinary research and teaching in Ecology. 5. Better scope to work for environmental NGOs.	

(Back to Index) (Back to Agenda)

Annexure II

Model Question paper, marking Schemes and List of the experiments for T. Y. B.Sc. Practical Examinations

Goa University
Taleigao Plateau, Goa
T.Y.B.Sc. Practical Examination in Botany, April, 20
Semester VI

BOC109: Molecular Biology and Genetic Engineering

Time: 9.30 to 1.30 pm **Maximum Marks: 50**

Instructions to the candidates:

1. *All the questions are compulsory.*
2. *Figure to the right indicates full marks.*
3. *Draw diagrams wherever necessary.*
4. *Candidates should show all the preparations to the examiners.*

Q.1. Perform the experiment allotted to you. **10 marks**
Q.2. Write the protocol of the given experiment. **5 marks**
Q.3. Identify the sequence from sequencing gel photograph/ calculate the size of fragment on restriction map given. **6 marks**
Q.4. Spotting: A, B, C. **9 marks**
Q.5.Viva-Voce. **10 marks**
Q.6. Journal. **10 marks**

- **Marking scheme- BOC109: Molecular Biology and Genetic Engineering**

Q.1. Perform the experiment allotted to you. **(10 marks)**
(For extraction of DNA and RNA)

Requirements	(1)
Principle	(2)
Procedure	(3)
Extraction	(3)
Expected Results	(1)

OR

Q.1. Perform the experiment allotted to you. **(10 marks)**
(For estimation of DNA and RNA)

Requirements	(1)
Principle	(2)
Procedure	(3)

Observation/ tabular columns/formula/ graphs & calculations. (3)
Results (1)

OR

Q.2. Protocol of the given experiment **(5 marks)**
Requirements (1)
Procedure (4)

Q3. Identify the sequence from sequencing gel photograph/ calculate the size of fragment on restriction map given. **(6 marks)**
Procedure (3)
Writing the sequence in 5' to 3' direction (3)

Q.4. Spotting: A, B, C **(9 marks)**

A. Identify and state the principle of the Instrument. (1+2)
B. Identify and comment on the photograph. (1+2)
C. Identify and enumerate the steps involved. (1+2)

Q.5.Viva-Voce. **(10 marks)**
Q.6. Journal. **(10 marks)**

- **List of Experiments - BOC109: Molecular Biology and Genetic Engineering**

Q.1. List of experiments (Any one).
a. Extraction of DNA from cauliflower.

b. Estimation of DNA by diphenylamine reagent.

c. Extraction of RNA from plant material. .
d. Estimation of RNA by Orcinol reagent.

Q.2. Protocols of the following:
Gel electrophoresis/Plasmid Culture/ Plasmid DNA extraction.

Q.3. Identify the sequence from sequencing gel photograph/ calculate the size of fragment on restriction map given.
Gel photographs of Maxam& Gilbert/ Sangers / restriction maps to be provided.

Q.4. **Spotting**

A. Photographs of Rolling circle, Theta replication, semi-discontinuous replication, RNA polymerase, eukaryotic RNA polymerase II, Avery et al, Griffith's, Hershey &Chase's Fraenkel & Conrat's experiments, splice some machinery and splicing mechanism of introns. (Any one)
B. Photographs of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato, humulin, *Agrobacterium*-mediated gene transfer, microprojectile bombardment (gene gun). (Any one)
C. Structures of pBR322, Ti plasmid, YAC, λphage through models/ photographs. (Any one)

(Back to Index) (Back to Agenda)