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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/103/1 Date:05.06.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/35 dated 20.08.2022

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Sciences in Botany** Programme is enclosed.

The Dean/ Vice-Deans of the School of Biological Sciences and Biotechnology is requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.06.05 17:00:40 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Deans, School of Biological Sciences and Biotechnology, Goa University.

Copy to:

1. The Chairperson, Board of Studies in Botany.
2. The Programme Director, M.Sc. Botany, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University

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
SEMESTER I		
Discipline Specific Core Courses		
BOT-500	Algae, Bryophyta, Pteridophyta, and Gymnosperms	3
BOT-501	Lab in Algae, Bryophyta, Pteridophyta, and Gymnosperms	1
BOT-502	Systematics of Angiosperms	3
BOT-503	Lab in Systematics of Angiosperms	1
BOT-504	Internal Morphology and Developmental Biology of Angiosperms.	3
BOT-505	Lab in Internal Morphology and Developmental Biology of Angiosperms	1
BOT-506	Plant Physiology	3
BOT-507	Lab in Plant Physiology	1
Discipline-Specific Elective Courses (Any 4 credits)		
BOT-521	Plant Biotechnology	3
BOT-522	Lab in Plant Biotechnology	1
BOT-523	Plant Biochemistry	3
BOT-524	Lab in Plant Biochemistry	1
SEMESTER II		
Discipline Specific Core Courses		
BOT-508	Microbiology and Plant Pathology	3
BOT-509	Lab in Microbiology and Plant Pathology	1
BOT-510	Cytogenetics and Plant Breeding	3
BOT-511	Lab in Cytogenetics and Plant Breeding	1
BOT-512	Plant Molecular Biology	3
BOT-513	Plant Genetic Engineering	3
BOT-514	Lab in Plant Molecular Biology and Genetic Engineering	2
Discipline-Specific Elective Courses (Any 4 credits)		
BOT-525	Modern Concepts in Plant Ecology	3
BOT-526	Lab in Modern Concepts in Plant Ecology	1
BOT-527	Mycorrhizal Biotechnology	2
BOT-528	Lab in Mycorrhizal Biotechnology	1
BOT-529	Introduction to Paleoflora	1

SEMESTER III		
Research Specific Elective Courses (Any 8 credits)		
BOT-600	Plant Histochemistry	3
BOT-601	Lab in Plant Histochemistry	1
BOT-602	Seed Science and Technology	3
BOT-603	Lab in Seed Science and technology	1
BOT-604	Genome Informatics	3
BOT-605	Lab in Genome Informatics	1
Generic Elective Courses (Any 12 credits)		
BOT-621	Introduction to Omics	3
BOT-622	Plant-Animal Interactions	4
BOT-623	Ecotourism	2
BOT-624	Lab in Ecotourism	2
BOT-625	Mushroom Biotechnology	1
BOT-626	Lab in Mushroom biotechnology	1
BOT-627	Marine Phytoplanktons	1
BOT-628	Oenology (Wine Science and Technology)	1
BOT-629	Lab in Oenology (Wine Science and Technology)	1
BOT-630	Ethnobotany	2
SEMESTER IV		
Research Specific Elective Courses (Any 4 credits)		
BOT-606	Research Methodology, Techniques, and Instrumentation	4
BOT-607	Applied Phycology: Utilization and Management	4
BOT-651	**Discipline Specific Dissertation**	16

SWAYAM COURSES **Recommended by BoS for the Post Graduate level**		
Course Code	**Title of the Course**	**Credit Equivalent**
	Discipline-Specific Generic Electives	
noc20-bt38	Wildlife Ecology	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
	Research Specific Electives	
cec20-ge29	Academic writing	4
cec20-bt23	Biostatistics and Mathematical Biology	3
noc20-bt31	Experimental Biotechnology	3
cec20-bt24	Biomass Characterization	4

SEMESTER I

Discipline Specific Core Courses

Name of the Programme: M. Sc (Botany)

Course Code: BOT-500

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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-501
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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-502
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; 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. 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. 4. **Numerical methods in taxonomy:** Phenetics, Principal Component Analysis, Discriminant Analyses. 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	**4 hours** **6 Hours** **7 hours** **4 hours** **8 hours**

	Bayesian). Phylogenomics as the modern trend in plant taxonomy. 6. **Phytogeography:** Basic terminologies and their understanding; Endemism- types and causes; vicariance; phytogeography and applications; phytogeographic regions of India and the world. 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 clades: Ordes- Amborellales, Nymphaeales, Austrobaileyales, Chloranthales; Clades (Magnoliids), (Monocots (Commelenids)), Order Ceratophyllales, (eudicots ((Superrrosids (Rosids, Fabids, Malvids))) and (Superasterids (asterids (campanulids, lamids))))).	**5 hours** **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. (4^{th} 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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-503
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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-504
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	**4 hours** **2 hours** **4 hours** **2 hours** **5 hours** **2 hours** **4 hours** **2 hours** **2 hours**

	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 hours**
	4. **Endosperm and embryogenesis:** Endosperm, embryo, nutrition and growth of embryo. Gene action during embryogenesis, storage compounds in endosperm and embryo, storage protein gene expression in transgenic systems; apomixis and polyembryony; applied aspects of embryology.	**4 hours**
	Palynology	
	1. **Pollen Biology:** Pollen morphological characters, Pollen wall features, pollen development and evolution of pollen types, palynology and taxonomy.	**3 hours**
	2. **Aeropalynology:** Methods of aerospora survey and analysis; pollen allergy and pollen calendars.	**2 hours**
	3. **Mellittopalynology:** Honey bee and pollen loads; role of apiaries in crop production.	**2 hours**
	4. **Palaeopalynology:** Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations.	**2 hours**
	5. Pollen biotechnology for crop production and improvement.	**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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-505
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. 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.***	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **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.	

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Name of the Programme: M. Sc Botany
Course Code: BOT-506
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. 5. **Dark reaction:** Carbon dioxide fixation in C3, C4 and CAM plants regulation of PCR cycle; photorespiration and its regulation, environmental factors affecting photosynthesis. 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. **Reactive oxygen species:** ROS generation, its oxidative effect on	**4 hours** **2 hours** **3 hours** **6 hours** **3 hours** **7 hours**

	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.	**6 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**
<u>Pedagogy</u>:	Lecture through PPT/E-learning/Assignments/Seminars/LSM Moodle.	
<u>References/ Readings:</u>	**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.	

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Name of the Programme: M. Sc Botany
Course Code: BOT-507
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. 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** **2 hours** **4 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **4 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.	

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Discipline Specific Elective Courses
Name of the Programme: M. Sc (Botany)
Course Code: BOT-521
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, Preparation of media, Selection of a suitable medium. Applications of Plant Tissue cultures.	**6 hours**
	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;	**8 hours**

	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. 9. **Introduction to gene transfer methods and transgenic plants:** Details of this topic is taught in **BOC-208** (Plant Genetic Engineering) 10. **Application of Biotechnology in Agriculture, Forestry and human welfare:** Marker assisted selection (MAS); Production of Biopesticides; Environmental and Enzyme biotechnology.	**1 hour** **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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-522
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. 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** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-523
Title of the course: Plant Biochemistry
Number of Credits: 3
Effective from AY: 2022-2023

Prerequisites for the course:	Students should have studied B. Sc. Botany with a basic knowledge of plant physiology and biochemistry at the UG level.	
Objective(s):	This paper provides a deeper understanding of isomerism of biomolecules, bio-membranes, bioenergetics and regulation of metabolic pathways in plants. Students will also learn the mechanism of enzyme action with an introduction to the cellular and molecular mechanisms of signal transduction.	
Content:	1. **Biomolecules:** Structure, function and isomerism of biomolecules; Organization and composition of eukaryotic cells; integration and control of cellular functions; amino acid composition of proteins; higher levels of protein organization; dynamic aspects of protein structure and protein stability. Plant biopolymers: Cellulose, hemicellulose, xylan and pectin. Biominerals in the plant such as phytoliths and calcium oxalate. 2. **Mechanism of enzyme action:** Introduction to enzymes; Michaelis-Menten model; enzyme kinetics as an approach to understanding mechanism; enzymatic reactions; Isozymes; regulatory enzymes; reversible and irreversible covalent modifications of enzymes. 3. **Metabolic pathways and regulation:** Major metabolic pathways and their regulation; biosynthesis of amino acids; purine and pyrimidine metabolism; metabolic interrelationships; biosynthesis of vitamins. 4. **Biomembranes and Bioenergetics:** Physico-chemical properties of biological membranes; structure of model membrane; lipid bilayer and membrane protein diffusion; their distribution and organization; intrinsic and extrinsic proteins; transport of biomolecules across the membrane; passive and active transport; membrane pumps, ion channels, role of the membrane in cellular metabolism. Bioenergetics: Thermodynamics; exergonic and endergonic reactions; redox potential; biological energy transducers; high energy compounds; oxidative phosphorylation; ATP structure and its significance. 5. **Expression and signal transduction:** Gene expression in eukaryotes; genetic control of enzyme synthesis; cell surface receptors; G proteins coupled secondary messenger and response to environmental changes and other stimuli.	**12 hours** **8 hours** **10 hours** **10 hours** **5 hours**
Pedagogy:	Lecture through PPT/e-learning/Assignments/Seminars/Self study.	

References/ Readings:	**Berg, Jeremy M** (2012) Biochemistry. WH Freeman and Company, New York. **Bowsher C** (2008) Plant Biochemistry. Garland Science, New York. **Brown TA** (2018) Biochemistry. Viva Books Pvt. Ltd., New Delhi. **Buchanan, Bob B** (2000) Biochemistry and Molecular Biology of Plants. Maryland American Society. **Buchanan, Bob B** (2007) Biochemistry and Molecular Biology of Plants. I K International Pvt. Ltd., New Delhi. **Campbell** D (1999) Biochemistry. Saunders College Publishing, Philadelphia. **Cooper GM** (2000) The Cell: A Molecular Approach. Sinauer Associates, Sunderland (MA). **Davies D** (1980) The Biochemistry of Plants. Academic Press, USA. **Devlin TM** (2011) Textbook of Biochemistry with Clinical Correlations. John Wiley and Sons, Inc., New York. **Donald V and Judith GV** (2011) Biochemistry. John Wiley and Sons Asia Pvt. Ltd., New Jersey. **Garret RH and Grisham CM** (2010) Biochemistry. Cengage Learning, Boston. **Hames D** (2005) Biochemistry. Taylor and Francis, New Delhi. **Hans-Walter Heldt and Birgit Piechulla**. (2021). Plant Biochemistry. Fifth Edition. Academic Press. **Heldt, Hans-Walter** (2005) Plant Biochemistry. Reed Elsevier India Pvt. Ltd., New Delhi. **Heldt, Hans-Walter** (2011) Plant Biochemistry. Academic Press, Amsterdam, USA. **Jones R** (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA. **Lehninger AL** (2013) Principles of Biochemistry. WH Freeman and Company, New York. **Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Scott MP** (2013) Molecular Cell Biology. WH Freeman and Company, New York. **Lubert S** (2002) Biochemistry. WH Freeman and Company, New York. **Metzler P, David E** (2006) Biochemistry. Elsevier India Pvt. Ltd., New Delhi. **Mishra SR** (2010) Plant Biochemistry.Discovery Publishing House Pvt. Ltd., New Delhi. **Mishra SR** (2011) Understanding Plant Biochemistry. Discovery Publishing House Pvt. Ltd., New Delhi. **Nelson DL, Cox MM and Lehninger AL** (2013) Principles of	

	Biochemistry. Freeman, New York. **Nicholas CP and Lewis S** (1999) Fundamentals of Enzymology. Oxford University Press Inc., New York. **Ochs, Raymond S** (2014) Biochemistry. Jones and Bartlett Learning, Burlington. **Rajan Katoch. (**2020). Fundamentals of Plant Biochemistry and Biotechnology. Kalyani Publishers, New Delhi. **Sheehan D** (2009) Physical Biochemistry. Wiley-Blackwell, West Sussex. **Sheehan M** (1994) Biochemistry and Molecular Biology. Thomas Nelson and Sons, United Kingdom. **Singh SK** (2009) Plant Physiology and Biochemistry. Campus Books International, New Delhi. **Voet DJ, Voet JG and Pratt** CW (2008) Principles of Biochemistry. John Wiley and Sons, Inc., New York. **Voet DJ** (1995) Biochemistry. John Wiley and Sons, New York.	
Learning Outcomes:	Students will be able to demonstrate a depth of knowledge of biochemical processes together with a better understanding of the interaction and regulation of various metabolic pathways.	

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Name of the Programme: M.Sc (Botany)
Course Code: BOT-524
Title of the course: Lab in Plant Biochemistry
Number of Credits: 1 (30 hours)
Effective from AY: 2022-2023

Prerequisites for the course:	Knowledge of the subject at the UG level to be able to prepare various types of solutions, and handle basic laboratory tools and techniques.	
Objective(s):	This course is designed primarily to relate the learning of concepts in the classroom to demonstrate an experimental foundation of underlying concepts/principles mainly on aspects of biomolecules, their metabolic processes and enzymes.	
Content:	1. Extraction and estimation of proteins from plants. 2. Extraction and estimation of amino acids from plants. 3. Extraction and estimation of total sugar and reducing sugars from plant samples. 4. Separation of protein by PAGE (preparation of gel, preparation of protein sample, running, development and documentation of gel). 5. Extraction and purification of lipids from leaf samples. 6. Separation of glycolipids, phospholipids and neutral lipids (chromatographically). 7. Quantitative estimation of phospholipids and glycolipids (spectrophotometrically). 8. Activity of enzyme phosphoenol pyruvate carboxylase (PEPC). ***Only 30 hours for any of the above practicals will be conducted depending on availability of materials, chemicals, equipments, etc.***	**4 hours** **4 hours** **4 hours** **6 hours** **2 hours** **6 hours** **4 hours** **2 hours**
Pedagogy:	Wet laboratory exercises	
References/ Readings:	**Bhainagar, R.** (1987) Manual of Practical Biochemistry. Delhi IBT Publishing, New Delhi. **Boyer, R.** (2000) Modern Experimental Biochemistry. Delhi Pearson Education, New Delhi. **Cooper, T.G.** (2011) The Tools of Biochemistry. Wiley India Pvt. Ltd., New Delhi. **Devi, P.** (2005). Principles and methods of Plant Molecular Biology, Biochemistry and Genetics. Jodhpur Agrobios, Jodhpur. **Harborne, J.B.** (2007) Phytochemical Methods. Chapmann and Hall, London. **Harisha, S.** (2006) Biotechnology Procedures and Experiments Handbook. Firewall Media, New Delhi. **Jayaraman, J.** (2011) Laboratory Manual in Biochemistry. John Wiley and Sons Ltd.	

	Palmer, T. & Bonner, T. (2003) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Woodhead Publishing House, Chichester, England. **Plummer, D.T.** (2014) An Introduction to Practical Biochemistry. Tata McGraw Hill publishing company Ltd., New Delhi. **Sadasivam, S. & Manickam, A.** (2009) Biochemical Methods. New Age International Pvt. Ltd. New Delhi. **Segel, I.H.** (2010) Biochemical Calculations. John Wiley and Sons, California, USA. **Sheehan, D.** (2009) Physical Biochemistry: Principles and Applications. John Wiley and Sons Ltd, Chichester, England. **Verma, P.**, Ashish, S. (2004) laboratory Manuel for Biotechnology. S Chand and Company, Ltd., New Delhi. **Wharton, David** (1972) Experiments and Methods in Biochemistry. The Macmillan Co., London. **Wilson, K. & Walker, J.** (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, UK.	
Learning Outcomes:	Students will be able to develop competence in handling various biochemical techniques and apply them in isolating and analyzing different biological molecules.	

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SEMESTER II

Discipline Specific Core Courses
Name of the Programme: M. Sc (Botany)
Course Code: BOT-508
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.	**2 hours** **5 hours** **5 hours**

	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 and sexual reproduction; Structural, functional and ecological specialization of fungal mycelia and spores; fungi in tropical habitats in relation to the plants.	**7 hours**
	5. **Study of different groups of fungi with suitable native examples:** Slime moulds, Chytridiomycota; Ooomycota; Glomeromycota; Zygomycota; Ascomycota and Basidiomycota.	**10 hours**
	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.	**8 hours**
	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.	**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:	1. Be able to identify microbial habitats and plant disease symptoms. 2. Be able to work in a field laboratory for mycological studies. 3. Gain better understanding of tropical microbial biodiversity and their ecological roles. 4. Have better prospects as plant pathologist in various farms. 5. Will be able to understand molecular basis of plant pathogen interaction and disease.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-509
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. 4. Isolation of endophytes and visualization of colony characteristics. 5. Maintenance of pure cultures of phylloplane, Rhizosphere and endophytic microflora using common microbiological media. 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. 7. Preparation of unstained and stained specimens of yeasts, fungi. Examination of gram character of bacteria. 8. SEM study of bacteria, fungi, plant viruses using electron dense stains. 9. Studying Phylogeny of plant viruses using bioinformatics tools. 10. Study of root nodulation, symbiosome, *Rhizobium*, leghemoglobin and Quorum Sensing in bacterial population. 11. Methods of isolation and culturing of fungi: colony characters; microscopic observations; morphology of hyphae and spores. 12. Study of reproductive structures of different genera of fungi. 13. Study of fungal physiology in pure colonies – characterization of fungal colonies. 14. Microfluidics in mycology- fabrication and application of microfluidics devices to fungal cultures for real time visualization of fungal metabolic activities. 15. Introduction to mycological databases and myco-systematics on Internet. 16. Introduction to Mycobioinformatics- tools and techniques (exercise to construct fungal phylogenetic tree to be given).	**2 hours** **4 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**

	17. Observation of different fungal substrates using sterile moist chamber incubation (e.g. herbivore dung; decomposing leaf-litter). 18. Observations on ecological succession of fungi; Terrestrial, marine and freshwater fungi. 19. Particle-plating technique for isolation of litter fungi. 20. Technique for isolation of fungal endophytes. 21. Isolation and serial dilution techniques (e.g. soil, dung and leaf litter). **Plant pathology** 22. Collection of infected specimens in the field and observation of symptoms. 23. Hand sections and tease mounts from infected plant specimens. 24. Study of viral, bacterial and fungal diseases of crop plants (cereal, vegetable, fruit, and plantations) from surrounding habitats in Goa. 25. Submission of 10 dried herbarium specimens of infected plant materials [fungal (4) +bacterial (3) + viral (3)] collected from nearby habitats. 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.***	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **4 hours**
<u>Pedagogy</u>:	Field visits and lab exercises/sample collections/use of electronic, digital and visual keys, herbarium production/videos/moodle guided exercises/mini projects/demonstration.	
<u>References/ Readings:</u>	**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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-510
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. 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. 3. **Chromosome theory of inheritance:** Association of paternal and maternal chromosomes at meiosis, Qualitative difference between chromosomes, Chromosome theory; Sex chromosomes and chromosome theory. 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. 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. 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. 7. **Molecular mechanisms to mutation and DNA repair**: Types	**5 hours** **4 hours** **2 hours** **6 hours** **3 hours** **4 hours** **4 hours**

	of mutations; Molecular basis of mutations; mutagens, mechanism of DNA repair. 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. 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. 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.	**5 hours** **4 hours** **4 hours** **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. 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:	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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-511
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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-512
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 and repressor; transcription factors, prokaryotic and eukaryotic transcription.	**7 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*.	**6 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. **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.	**7 hours** **7 hours**
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.	

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Name of the Programme: M. Sc Botany
Course Code: BOT-513
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 transformation and its application. Other direct gene transfer methods. Conventional Plant Breeding vs Genetic Engineering. 4. **Site directed mutagenesis:** DNA sequencing, various strategies for carrying out site directed mutagenesis. 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. 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	**2 hours** **8 hours** **6 hours** **3 hours** **8 hours** **8 hours**

	methods of sequencing, PCR, RT-PCR and microarrays. 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.	**7 hours** **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 BOT-512 (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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-514
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. 13. Use of software for quantitation of gene and compare the expression level. 14. Southern Blotting/Northern Blotting/Western Blotting (any one) 15. Creating a transformant using commercial construct. 16. 16 or 18s rRNA analysis. 17. Leaf disc transformation using Agrobacterium, establishment of transgenic plants and GUS staining of GFP viewing. 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. ***Only 60 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** **4 hours** **2 hours** **2 hours** **2 hours** **4 hours** **8 hours** **2 hours** **4 hours** **4 hours** **4 hours** **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.W., Tania A.B., Stephen P.B., Alexander G., Michael L. & Richard L. (**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 & 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.	

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Discipline Specific Elective Courses
Name of the Programme: M. Sc (Botany)
Course Code: BOT-525
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. 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. 4. **Molecular and Evolutionary Ecology:** Rapid evolution and ecological consequences; community phylogenetics;	**6 Hours** **12 Hours** **7 Hours** **7 Hours**

	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.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-526
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. Study of local landscapes using maps/satellite images/modelling tools. 3. Study of stratification and physiognomy. 4. Study of vegetation by sampling methods (Transect/Bisect/Trisect/Ring counts/Quadrat method). 5. To assess the trophic status of aquatic habitat through algal count method. 6. Effect of abundance of single species populations on community in aquatic ecosystem. 7. Phytogeographic analysis preferably using BEAST software. 8. Community phylogenetics. 9. Analysis of MODIS products for global vegetation phenology and productivity. 10. Use of MAXENT modeler for predicting species distributions. 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. 12. Study of effect of effluents on growth of plants. 13. To study indices of similarity & dissimilarity in a community. 14. Analysis of plant communities through qualitative and remote sensing methods, Statistical tools and softwares. 15. Performing Rapid EIA using Leopold interaction matrix (different projects). 16. Community composition of plankton community. 17. Effect of zooplankton grazing on phytoplankton communities. 18. Pool size v/s Diversity of aquatic plants.	**2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **4 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **4 Hours** **2 Hours** **2 Hours** **2 Hours** **4 Hours** **2 Hours**

	19. Study of density of single species on growth rate. 20. Assessing the gene flow among populations using molecular markers. 21. Estimation of effective population sizes from data on genetic markers. 22. Survey of key stone species. 23. Study of technical reports on Solid waste Management. 24. Performing rapid biological impact analysis. 25. Software for EIA-solid waste management. 26. Field visit – data collection and report preparation. 27. Biodiversity assessment of forest tree community. 28. Assessment of forest disturbance for conservation aspects. ***Only 30 hours for any of the above practicals will be conducted depending on availability of plant material, chemicals, equipments, etc.***	**2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours** **2 Hours**
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.	

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Name of the Programme: M. Sc. (Botany)
Course Code: BOT-527
Title of the Course: Mycorrhizal Biotechnology
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Mycology.	
Objective:	To familiarize the students with various aspects of Mycorrhizal fungi, study techniques and their applications.	
Content:	1. **Biofertilizers:** Definition, types, characteristic features, their role and importance in sustainable agriculture. 2. **Mycorrhiza**: Definition and historical perspective; Types of mycorrhizae; classification; Phylogeny; general importance. 3. **Mycorrhizal Techniques:** Isolation and pure culture preparation of ecto- and endo-mycorrhizae; Criteria for identification - generic and specific level; staining techniques; Trap and pure cultures; *in vitro* culture of AM fungi, commercial production of inoculum. 4. **Molecular and cell biology of AM symbiosis:** Fungal partner; Cytological features of AM plant roots. Transfer of nutrients between plants and fungi; Defense reaction during colonization; Signaling pathways in AM fungi. 5. **Phosphate transport and role of AM fungi:** Developmental stages during mycorrhiza formation, Pathways in P uptake; Sources of P, C: N ratio; P uptake from the environment; Plant phosphate transporters. 6. **Phytohormones and AM symbiosis:** Cytokinins, Gibberellins, Ethylene, ABA, Auxins, Salicylic acid, Jasmonic acid; Role of Jasmonates in mycorrhization. 7. **Ecology of AM fungi:** Mycorrhiza formation in field soil; effects of N and micronutrients. Microbial interactions, phytoremediation; Effects on AM fungi – disturbance, agrochemicals and grazing. 8. **Production of ectomycorrhizal fungal inocula and inoculation procedures:** Types of ecto-mycorrhizal inocula; Methods of preparation, inoculum procedures. 9. **Mycorrhizae in phytoremediation:** Phytoremediation – definition, advantages and limitations; Contaminated and uncontaminated soils, heavy metals and their effects in plants; Heavy metal detoxification mechanisms in plants and AM fungi; Phyto-stabilization and phytoextraction; Glomalin and its role; concepts for improving phytoremediation by plant engineering.	**4 hours** **4 hours** **3 hours** **4 hours** **3 hours** **2 hours** **3 hours** **3 hours** **4 hours**
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	
References/ Readings:	**Allan, M. F.** (1991). The Ecology of Mycorrhizae. Cambridge University Press.	

	Bacon, C. W. and White, J. H. (2000). Microbial Endophytes Marcel Dekker, New York. **Dwivedi, B. K. and Pandey, G. (**1994). Biotechnology in India. Allahabad: Bioved Research Society. **Patel, S., Sharma, A., & Batra, N. G.** (2022). Arbuscular Mycorrhizal Fungi-Assisted Bioremediation of Heavy Metals: A Revaluation. In Innovations in Environmental Biotechnology. Springer, Singapore. **Read, D. J., *et al.*** (1996). Mycorrhizas in Ecosystems. Oxford University Press. **Rodrigues, B. F. and Muthukumar, T.** (2009). Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 pp. **Satyanarayana, T., Deshmukh, S. K., & Deshpande, M. V.** (2021). Progress in Mycology. Springer Singapore. **Schenck, N. C. (**1982). Methods and principles of mycorrhizal research. St. Paul Minnesota. **Schenck, N.C. and Perez, Y.** (1990). Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. **Sylvia, D. M., et al. (**1987). Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. **Willis, A., *et al.*** (2013). The ecology of arbuscular mycorrhizal fungi. Critical Reviews in Plant Sciences 32:1-20.	
Learning Outcomes:	Better prospects in agro-based industries.	

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Name of the Programme: M. Sc. (Botany)
Course Code: BOT-528
Title of the Course: Lab in Mycorrhizal Biotechnology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Mycology.	
Objective(s):	Exercises are designed so that the students will have hands-on training in mycorrhizal biotechnology and development.	
Content:	1. Isolation of AM fungal spores from rhizosphere soil. 2. Estimation of AM fungal spore numbers. 3. Techniques of staining roots for AM colonization. 4. Histochemical staining for polyphosphate granules in AM fungal hyphae using Toluidine blue O (TBO). 5. Histochemical staining for lipid bodies in AM fungal hyphae and vesicles using Sudan Black. 6. Preparation of AM fungal inocula: trap and pure cultures. 7. Identification of some commonly occurring AM fungal species based on spore morphology. 8. *In vitro* culture of AM fungi.	**2 hours** **4 hours** **4 hours** **2 hours** **2 hours** **6 hours** **6 hours** **4 hours**
Pedagogy:	Laboratory Practicals.	
References/ Readings:	**Allan, M. F.** (1991). The Ecology of Mycorrhizae. Cambridge University Press. **Bacon, C. W. and White, J. H.** (2000). Microbial Endophytes Marcel Dekker, New York. **Dwivedi, B. K. and Pandey, G. (**1994). Biotechnology in India. Allahabad: Bioved Research Society. **Read, D. J., Lewis, D. H. Fitter, A. H. and Alexander, I. J.** (1996). Mycorrhizas in Ecosystems. Oxford University Press. **Rodrigues, B. F. and Muthukumar, T.** (2009). Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 pp. **Schenck, N. C. (**1982). Methods and principles of mycorrhizal research. St. Paul Minnesota. **Schenck, N.C. and Perez, Y.** (1990). Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. **Sylvia, D. M., Hung, L. L. and Graham, J. H.** (1987). Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. **Willis, A., B. F. Rodrigues, and Harris, P.J.C.** (2013). The ecology of arbuscular mycorrhizal fungi. Critical Reviews in Plant Sciences 32:1-20.	
Learning Outcomes:	Better prospects in agro-based industries.	

Name of the Programme: M. Sc. (Botany)
Course Code: BOT-529
Title of the Course: Introduction to Paleoflora
Number of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective(s):	To understand evolutionary structures and processes in Plant groups.	
Content:	1. Introduction and scope of Paleobotany, Geological eras. 2. Conditions favouring preservations of fossil plants. 3. Classification of fossil plants. The naming of fossil plants 4. Process of fossilization. 5. Non-vascular plants- Bacteria, algae, Algal lime-stones, fossil bryophytes and their evolution. 6. Early vascular plants - Psilophytales, Ancient Lycopods, Equisetales Rhyniales, Sphenophyllales with their evolutionary evidences; fossil ferns foliage, ancient ferns and their evolution. 7. Pteridospermales, Glossopteridales, Ginkgoales, Cordaitales and Coniferales and their evolution. 8. Ancient flowering plants and evolution.	**1 hour** **1 hour** **2 hours** **1 hour** **2 hours** **4 hours** **3 hours** **1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-study.	
References/ Readings:	**Arnold CA.** (1947) An introduction to Paleobotany. New York: McGraw Hill Book Company, Inc **Agashe, S. N.** (1995). Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. **Banks HP.** (1970) Evolution of plants of the past. Belmont, CA: Wadsworth Publishing Company; Fundamentals of Botany Series. **Kenrick P. Davis P.** (2004) Fossil plants. The Natural History Musuem. London **Meyen, S.** (2012). Fundamentals of palaeobotany. Chapman and Hall N. Y Springer Science & Business Media. **Taylor T.N, Taylor EL, Krings M.** (2009) Paleobotany: The biology and evolution of fossil plants. 2nd edn: Academic Press Amsterdam.	
Learning Outcomes:	1. Being able to understand the evolution of plants in geological epochs. 2. Being able to understand the importance of fossil plants in conservation.	

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SEMESTER III

Research Specific Elective Courses
Name of the Programme: M. Sc (Botany)
Course Code: BOT-600
Title of the course: Plant Histochemistry
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	To impart knowledge related to structure and development of plants. To impart knowledge on applications of microscopy and use of instrumentation. To impart knowledge on methods and procedures employed for localization of various storage compounds such as carbohydrates, protein, lipids, minerals such as calcium, potassium, iron, and other chemical compounds present in different parts of plants using fluorescent and non-fluorescent dyes.	
Content:	1. **Introduction to basic histology:** Cells, tissues, and microorganisms. 2. **General Techniques:** Chemistry and practice of fixation; whole mounts; sectioning-microtomy, cryo- and ultra-microtomy; freeze-drying of biological materials. 3. **Microscopy:** Light-matter interaction and its significance; Kohler illumination; Principles, instrumentation, and applications of bright-field, polarization, phase-contrast, fluorescence, confocal; image analyzing system. 4. **Cyto- and histo-chemistry with bright-field microscopy:** Single and double staining protocols; localization of various biogenic components such as carbohydrates, proteins, lipids, nucleic acids, phenolic compounds, lignins, cutins, suberin, waxes, minerals such as calcium, potassium, irons and other metals. 5. **Polarization microscopy:** Study of structure and components of the cell wall, starch, crystals, and other anisotropic materials. 6. **Fluorescence microscopy:** Auto-fluorescence in biological materials; fluorochromes; excitation filters; localization of proteins, lysine-rich proteins, lipids, nucleic acids, phytins, phenolic compounds, lignins, and cutins in various biological tissues using fluorescent dyes; Role of fluorescein isothiocyanate (FITC) bound dextrins and vascular tissue-specific fluorochromes in biology; study of cell membranes, connective tissues, protoplasts, and infected materials. 7. **Histochemical localization of secondary metabolites:** Alkaloids, Phenolic compounds, Terpenoids, and other	**1 hour** **3 hours** **12 hours** **5 hours** **2 hours** **5 hours** **3 hours**

	compounds. 8. **Electron microscopy:** Principles, instrumentation, and applications of Scanning Electron Microscopy (S.E.M.) and Transmission Electron Microscopy (T.E.M.). Specimen preparation for T.E.M. and S.E.M. 9. **Enzyme histochemistry:** Localization of esterases, phosphates, and other enzymes. 10. **Immunohistochemistry and its application.** 11. **Photomicrography:** Basic techniques of image capturing and image analysis using bight-field, polarization, dark-field, and fluorescence microscopy; Conventional and digital photography; basic principles, cameras, lenses, focusing, exposure, resolution, depth of field, lighting, keeping and storing records. 12. **Cyto-histochemistry and its applications:** Understanding biological structures of medicinal and other economically important plants; Applications in diagnostic and analytical sciences and biotechnology.	**3 hours** **2 hours** **1 hour** **4 hours** **4 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars.	
References/ Readings:	**Chakraborty M.** (2012). Histology and Histochemistry, Wisdom Press, New Delhi. **Clark, G.** (1981). Staining Procedures, Williams and Wilkins, Baltimore, U.S.A. **Conn. H.J.** (1977). Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, U.S.A. **David L. Spector and Robert D. Goldman.** (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. **Demarco, D.** (2017). Histochemical analysis of plant secretory structures. In Histochemistry of single molecules (pp. 313-330). Humana Press, New York, NY. **Gartner, L.P. and Hiatt, J.L.** (2006). Color Textbook of Histology e-book. Elsevier Health Sciences. **Hayat, M.A.** (1986). Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. **Jensen, W.A.** (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, U.S.A. **Kiernan J.A.** (2015). Histological and Histochemical Methods: Theory and Practice (5th edition), Scion Publishing Ltd., U.K. **Krishnamurthy, K.V.** (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. **Lacey, A. J.** (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, U.K. **Pears, A.G.E.** (1980). Histochemistry Theoretical and Applied,	

	Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. **Shyamasundari, K. and K. Rao H.** (2007). Histochemistry in focus. A Sourcebook of techniques and research needs, M.J.P. Publishers, Chennai. **Zhou, J. and Xi'an J.** (2017). Histochemistry, University Press Co. Germany: De Gruyter.	
Learning Outcomes:	1. Will enable to gain insight into the fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand the development of various plant species. 2. Will enable to select appropriate stains to differentiate plant tissues in different stages of development. 3. Will enable to apply methods and procedures for the localization of various compounds, enzymes, minerals, *etc.* 4. Will promote prospects in pharmacognosy.	

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Name of the Programme: M.Sc (Botany)
Course Code: BOT-601
Title of the course: Lab in Plant Histochemistry
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	To learn and understand various microscopic and histochemical techniques. To understand the localization of various storage compounds such as starch, protein, lipids, minerals, secondary metabolites, and other compounds using different fluorescent and non-fluorescent dyes.	
Content:	1. Study of auto-fluorescence in biological specimens using U.V., violet, blue and green excitation filters under fluorescence microscopy. 2. Localization of proteins in biological tissues using fluorescent and non-fluorescent dyes. 3. Localization of lipids in biological tissues using fluorescent and non-fluorescent dyes. 4. Study the distribution of starch in biological specimens using iodine potassium iodide. 5. Study the structure of starch, stomata, crystalline, and other anisotropic materials using polarization microscopy. 6. Examination of normal and diseased plant tissues using fluorescence microscopy. 7. Microphotography using bright-field, dark-field, polarization, and fluorescence microscopy. 8. Demonstration of image capture, image analysis, and measurement of various parameters of cells and tissues using image analyzing software. 9. Demonstration of Scanning Electron Microscopy (S.E.M.). 10. Extraction of natural dyes from plants. 11. Evaluation of natural dyes as biological stains.	**4 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**
Pedagogy:	Hands-on Practical/Demonstrations.	
References/ Readings:	**Clark, G.** (1981). Staining Procedures, Williams and Wilkins, Baltimore, U.S.A. Conn. H.J. 1977. Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, U.S.A. **David L. Spector and Robert D. Goldman.** (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. **Hayat, M.A.** (1986). Basic Techniques for Transmission Electron	

	Microscopy. Academic Press. London and New York. **Jensen, W.A.** (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, U.S.A. **Kiernan John A.** (2015). Histological and Histochemical Methods: Theory and Practice (5th edition), Scion Publishing Ltd., U.K. **Krishnamurthy, K.V.** (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers and Publishers) Pvt. Ltd., Chennai. **Lacey, A. J.** (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, U.K. **Meenakshi Chakraborty.** (2012). Histology and Histochemistry, Wisdom Press, New Delhi. **Pears, A.G.E.** (1980). Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. **Pears, A.G.E.** (1985). Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York. **Sharma, V. K.** (1991). Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi. **Shyamasundari, K. and K. Hanumantha Rao.** (2007). Histochemistry in focus. A Sourcebook of techniques and research needs, M.J.P. Publishers, Chennai. **Zhou, J. and Xi'an Jiaotong** (2017). Histochemistry, University Press Co. Germany: De Gruyter.	
Learning Outcomes:	1. Will enable to gain insight into fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand the development of various plant species. 2. Will enable the selection of appropriate stains to differentiate plant tissues in different stages of development. 3. Will enable to apply methods and procedures for the localization of various compounds, enzymes, minerals, primary and secondary metabolites, *etc*. 4. Will enable extraction and use natural dyes as biological stains. 5. Woll promote prospects in pharmacognosy.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-602
Title of the Course: Seed Science and Technology
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	To facilitate a deeper understanding of various aspects of seed science and technology.	
Content:	1. **Concept of seed technology**: Seed quality, definition, importance, and goals of seed technology; types of seed programmes; Steps involved in developing a seed programme. Characters of good quality seeds, Seed development and maturation.	**5 hours**
	2. **General Principals of seed production and Seed Processing:** Genetic and agronomic principles; Maintenance of nucleus seed; production of Breeder, Foundation, and Certified seed; principles of seed processing; methods of seed drying.	**5 hours**
	3. **Seed cleaning equipment and their functions:** Functions of Scalper, Debearder, Scarifier, Huller, Seed Cleaner, and Grader. Screen cleaners, specific gravity separators, indented cylinders, velvet-spiral-disc separators, colour sorters, and delinting machines.	**5 hours**
	4. **Seed treatment:** Types of seed treatment, seed treating formulations and equipment, seed disinfestations, identification of treated seeds; packaging materials: principles, practices, and materials; bagging and labelling. Seed quality enhancement techniques, seed priming, seed coating, and seed pelleting.	**5 hours**
	5. **Seed storage:** Principles of seed storage; seed drying, the importance of seed drying; factors affecting seed longevity during storage, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Measures for pest and disease control during storage and godown sanitation; Storage structures. Storage problems of recalcitrant seeds and their conservation. Genetic changes during seed storage; Seed marketing structure and organization; factors affecting seed marketing and demand.	**10 hours**
	6. **Seed germination methods:** Germination-phases of seed germination; Dormancy-types of seed dormancy; T.T.C. test; Embryo excision method.	**5 hours**
	7. **Field Inspection:** Method of inspection; field counts; field and seed standards; post-harvest inspection; specifications for tags and labels. Duties and powers of Seed Inspector.	**3 hours**
	8. **Seed Certification:** Objectives of seed certification; legal status	**3 hours**

	and phases of seed certification; procedure for seed certification; formulation, revision, and publication of seed certification standards. 9. **Seed Legislation and Seed Law Enforcement:** Seed Act and rules; Seed Legislation in India; Regulatory legislations; Seed Law Enforcement; Seed Control Order, 1983; The Plant Varieties Act, National Seed Policy 2002; Seed Bill 2004.	**4 hours**
Pedagogy:	Lectures/Assignments/Moodle/Tutorials/Seminars.	
References/ Readings:	**Agarwal, R. L.** (2018). Seed Technology. India: Oxford and I.B.H. Publishing Company Pvt. Limited. **Agrawal P.K.** (1993). Handbook of Seed Testing. Ministry of Agriculture, G.O.I., New Delhi. **Agrawal P.K. and Dadlani M.** (1992). Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **Copland L.O. and McDonald M.B.** (1996). Principles of Seed Science and Technology. Kluwer. **ISTA (**2006). Seed Testing Manual. ISTA, Switzerland. **Joshi, A.K. and B.D. Singh.** (2004). Seed Science and Technology. Kalyani Publishers, New Delhi. **Martin C. and Barkley D.** (1961). Seed Identification Manual. Oxford & I.B.H. Berkeley, University of California Press. **Payasi S. K. and Katkani D.** (2021). Technology. Brillion Publishers, New Delhi. **Sai Prasad S.V., Verma S and Jat D.** (2018). Seed Science and Technology. New Vishal Publications, New Delhi. **Singh P.** (2013). Principles of Seed Technology. Kalyani Publishers, New Delhi. **Subir Sen and Nabinananda Ghosh.** (2014). Seed Science and Technology. Kalyani Publishers, New Delhi. **Tunwar N.S. and Singh S.V.** (1988). Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes:	1. Will enable to work in seed banks and plant nurseries. 2. Will help to educate farmers and seed producers. 3. Will enable to run seed distribution outlets. 4. Will enable to work as market watchdog to detect spurious seeds. Will enable to work as seed collector.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-603
Title of the Course: Lab in Seed Science and Technology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	To facilitate a deeper understanding of various aspects of seed science and technology.	
Content:	1. Identification of seeds of weeds and crops. 2. Physical purity analysis of samples of different crops. 3. Estimation of seed moisture content (oven method). 4. Seed dormancy breaking methods requirements for conducting germination test. 5. Seed germination testing in different agri-horticultural crops. 6. Viability testing by tetrazolium test in different crops. 7. Seed and seedling vigour tests. 8. Effect of drying temperature and duration on seed germination. 9. Testing coated/pelleted seeds. 10. Study of orthodox, intermediary, and recalcitrant seeds. 11. Global seed germplasm resources and their conservation. 12. To test the membrane permeability of the seeds.	**2 hours** **2 hours** **2 hours** **4 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Practicals/Demonstrations	
References/ Readings:	**Agarwal R.L.** (2007). Seed Technology. Oxford and I.B.H. **Agrawal P.K. and Dadlani M.** (1992). Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **Agrawal P.K.** (1993). Handbook of Seed Testing. Ministry of Agriculture, G.O.I., New Delhi. **Copland L.O. and McDonald M.B.** (1996). Principles of Seed Science and Technology. Kluwer. **ISTA** (2006). Seed Testing Manual. ISTA, Switzerland. **McDonald, M. F. and Copeland, L. O.** (2012). Principles of Seed Science and Technology. United States: Springer US. **Martin A.C. and Barkley W.D.** (2018). Seed Identification Manual. Scientific Publishers. **Tunwar N.S. and Singh S.V.** (1988). Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes:	1. Will be able to carry out seed germination tests. 2. Will be able to work in seed testing labs and commercial seed companies.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-604
Title of the Course: Genome Informatics
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of molecular biology and computers.	
Objective(s):	To impart hands-on trai ning in public domain software tools, demos, and mini-projects.To assist the students in picking up the minimum required skill sets demanded by bio-industries. To impart basic knowledge in the analysis of genome and proteome.	
Content:	1. **Introduction to Genome Informatics**: Nature of biological data, Overview of available bioinformatics resources on the web (Web based and command line softwares), National Centre for Biotechnlogy Information (NCBI), European Bioinformatics Institute (E.B.I.), Expert Protein Analysis System (EXPASY), ENSEMBL; Biological Databases: Nucleic acid sequence databases, GenBank, European Molecular Biology Laboratory (EMBL), D.N.A. Databank of Japan (DDBJ); Protein sequence databases, Protein Data Bank (PDB), SwissProt/UniProtKB; Genome databases of model organisms (Plants, microbes, other organisms): Online Mendelian Inheritance in Man (OMIM), Ensembl-Plants, EMBL, Reference sequence (refseq), The Single Nucleotide Polymorphism Database (dbSNP), structural databases: Molecular Modelling Database (MMDb), Nucleic Acid Database (N.D.B.), Complex Carbohydrate Structure Database (CCSD), derived databases, PROSITE, BLOCKS, STRING, Pfam/Prodom, Database search engines, Entrez, S.R.S., TAIR (The Arabidopsis Information Resource), The Rice Genome Annotation Project (TAGAP), Plant MPSS (Massively Parallel Signature Sequencing) database. 2. **Overview/concepts in sequence analysis**: Evolutionary basis of sequence alignment; Pairwise sequence alignment algorithms, Needleman and Wunsch, Smith and Waterman; Scoring matrices for nucleic acids and proteins, Multiple Domain Matrix (M.D.M.), Blocks Substitution Matrix (BLOSUM), Point Accepted Mutation (P.A.M.), Gap Penalties; Motifs, Domains and Patterns; Database Similarity Searches – Basic Local Alignment Search Tool (BLAST), Multiple sequence alignment, Progressive sequence alignment, Parallel Multiple Sequence Alignment Package (PRAS), CLUSTAL-W. 3. **Structural biology and molecular modelling**: Proteins - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure, Nucleic acid - D.N.A. and R.N.A., Carbohydrates, 3D viral structures; 3D structure visualization and simulation; Concepts in molecular modelling and introduction to	**8 hours** **8 hours** **8 hours**

	molecular modelling methods; Methods to study 3D structure, analysis of 3D structures. Principles of protein folding and methods to study protein folding: CATH (Protein Structure Classification Database), SCOP (Structural Classification of Protein Database), FSSP (Families of Structurally Similar Proteins), Ramachandran plot; Macromolecular interactions, Protein-Protein, Protein-nucleic acids, Protein-carbohydrates. 4. **Phylogenetic analysis:** Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (N.J.), Maximum Parsimony (M.P.), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. D.N.A. barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD). 5. **Analysis of D.N.A. and Protein Microarrays:** Designing of oligo probes; primers, promoters; Analysis of Genomics sequences, promoter sequences-MEME (Motif Based Sequence Analysis Tool), e-plant, PLANTCARE, R.N.A. sequences; Analysis of D.N.A. for cloning: Tools, Softwares used; Image processing and normalization; Microarray data variability (measurement and quantification); Analysis of differentially expressed genes; Experimental designs, Analysis of Next Generation Sequencing data and R.N.A. sequencing data, plant G.D.B. for comparative Genomics. 6. **Applications in drug design:** Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of binding sites and virtual screening; Ligand based drug design: Structure-Activity Relationship – QSARs (Quantitative Structure-Activity Relationship Model) and Pharmacophore; in silico predictions of drug activity and ADMET (Absorption, Distribution, Metabolism, and Excretion), Molecular Docking.	**7 hours** **7 hours** **7 hours**
Pedagogy:	Lectures/Tutorials/Seminars/Assignments.	
References/ Readings:	**Andrew Leach**. (2001). Molecular Modelling: Principles and Applications, Prentice Hall. **Antao, T.** (2018). Bioinformatics with Python Cookbook: Learn how to use modern Python bioinformatics libraries and applications to do cutting-edge research in computational biology. Packt Publishing Ltd. **Attwood, T. K., Parry-Smith, D. J. and Phukan S.** (2022). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd. **Baxevanis, A.D., Davison, D.B., Page, R.D.M. and Petsko, G.A**. 2004. Current Protocols in Bioinformatics by, New York, John	

Wiley and Sons Inc.

Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., and Lapeyre, B. (2008). Practical Bioinformatics. Springer.

Davies T.M. (2016). The Book of R: A First Course in Programming and Statistics. No Starch Press, New Zealand.

Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press.

Fasman, G.D. (1989). Prediction of protein structure and the principles of protein conformation. New York. Plenum Press.

Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. (2002). Computational methods for protein folding: advances in chemical physics vol. 120. New York. John Wiley and sons, Inc. Publication.

Gimona, G. Cesareni and Yaffe, M. Sudol (Eds). (2004). Modular protein domains, USA, Wiley-vch Verlag gmbh and co. 3-527-30813-X.

Gundertofte, K. and Jorgensen, F.S. (2000). Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers.

Madhavan, G. (2006). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Edited by Andreas D. Baxevanis and BF Francis Ouellette, ISBN: 0-471-47878-4.

Maulik, U., Bandyopadhyay, S., and Mukhopadhyay, A. (2011). Multiobjective genetic algorithms for clustering: applications in data mining and bioinformatics. Springer Science and Business Media.

Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press.

Rastogi, S.C., Mediratta, N. and Rastogi. P. 4th ed (2013). Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice Hall of India, Pvt. Ltd., New Delhi.

Solomon K.A. (2011). Molecular Modelling and Drug Design. MJ publisher.

Stephen Misener and Stephen Krawetz. (2004). Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint

Webster, D.M. Ed. (2000). Protein structure prediction: methods and protocols, Totowa Humana Press, 2000.

Public domain database/tools/resources

- DBGET-http://www.genome.jp/dbget/
- LinkDB-http://www.genome.jp/dbget/linkdb.html

	• Fgeneshttp://www.softberry.com/berry.phtml?topic=products GeneBuilder • http://www.itb.cnr.it/sun/webgene/ • GeneSCAN-http://genes.mit.edu/GENSCAN.html • GRAIL-http://compbio.ornl.gov/Grail-1.3/ • CLC Free Workbench http://www.clcbio.com/index.php?id=28 BioEditor-http://bioeditor.sdsc.edu/ • CN3D 4.1 - http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml Protein Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm • Chimera-http://www.cgl.ucsf.edu/chimera/ • Yasara-http://www.yasara.comhttp://www.yasara.com) • Ribosome builder-http://rbuilder.sourceforge.net/ • ArrayExpress-www.ebi.ac.uk/arrayexpress/ • EPICLUST-http://ep.ebi.ac.uk/EP/	
Learning Outcomes:	1. Will enable to understand the basic theory of computational tools and to gain working knowledge. 2. Will enable to analyze Next Generation Sequencing (NGS) raw data. 3. Will be better equipped to investigate specific contemporary biological questions.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-605
Title of the Course: Lab in Genome Informatics
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of molecular biology and computers.	
Objective(s):	To provide practical experience in using standard computational tools and databases. To facilitate the investigation of molecular biology and evolution-related concepts. To train in modern methods of biological analysis.	
Content:	1. Exploring National Centre for Biotechnology Information (NCBI) database, PUBMED and GenBank databases, (NCBI), European Bioinformatics Institute (E.B.I.) server, and searching the European Molecular Biology Laboratory (EMBL) Nucleotide database, Entrez (Global Query Cross-Database Search System), SWISSPROT & UniProtKB.	**2 hours**
	2. Sequence retrieval of D.N.A. and Protein from different databases.	**2 hours**
	3. Homology searches using different versions of the Basic Local Alignment Search Tool (BLAST) and interpretation of the results to derive the biologically significant relationships of the query sequences (proteins/D.N.A.) with the database sequences.	**2 hours**
	4. Use of scoring matrices, Pair-wise local alignments of protein, and D.N.A. sequences using the Smith-Waterman algorithm and interpretation of results.	**2 hours**
	5. Multiple sequence alignments of sets of sequences using the web-based and stand-alone version of CLUSTAL. Interpretation of results to identify conserved and variable regions and correlate them with physico-chemical and structural properties.	**2 hours**
	6. Search and retrieval: genomic data at NCBI server, Interpreting D.N.A. and Protein microarray data.	**2 hours**
	7. Use of gene prediction methods (Genscan,/Glimmer), various primer designing, and restriction site prediction tools.	**2 hours**
	8. Promoter analysis of different genes and T.F. binding sites.	**2 hours**
	9. Use of different protein structure prediction databases Protein data bank (PDB), SCOP Structural Classification of Protein Database (SCOP), Protein Structure Classification Database (CATH).	**2 hours**
	10. Exploring and using the derived databases: PROSITE, PRINTS, BLOCKS, Pfam, and Prodom for pattern searching, domain searches, etc.).	**2 hours**
	11. Protein-protein interaction study tools.	**2 hours**

	12. Construction and study of protein structures using RASMOL/Deepview/PyMol. Homology modelling of proteins. Use of tools for mutation and analysis of protein structures. 13. Phylogenetic analysis of protein and nucleotide sequences, tree building, databases for barcoding. 14. Use of galaxy tool for D.N.A. sequence analysis and NGS data. 15. Use of R language in data analysis.	**2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Internet-based tools, hands-on and group exercises, videos, moodle guided exercises, and expert lectures.	
References/ Readings:	**Andrew Leach.** (2001). Molecular Modelling: Principles and Applications, Prentice Hall. **Antao, T.** (2018). Bioinformatics with Python Cookbook: Learn how to use modern Python bioinformatics libraries and applications to do cutting-edge research in computational biology. Packt Publishing Ltd. **Attwood, T. K., Parry-Smith, D. J. and Phukan S.** (2022). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Pvt. Ltd. **Bajorath J.** (2004) Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press. **Baxevanis, A.D., Davison, D.B., Page, R.D.M., and Petsko, G.A.** (2004) Current Protocols in Bioinformatics by, New York, John Wiley & Sons Inc. **Bourne Philip E. and Weissig Helge** (2003). Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss. **Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., and Lapeyre, B.** (2008). Practical Bioinformatics. Springer. **Davies T.M.** (2016). The Book of R: A First Course in Programming and Statistics. No Starch Press, New Zealand. **Dov Stekel**, (2003) Microarray Bioinformatics; Cambridge University Press. **Fasman, G.D.** (1989). Prediction of protein structure and the principles of protein conformation. New York. Plenum Press. **Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A.** (2002). Computational methods for protein folding: Advances in chemical physics vol. 120. New York. John Wiley and Sons, Inc. Publication. **Gimona, G. Cesareni and Yaffe, M. Sudol** (Eds.). (2004). Modular protein domains, USA, Wiley-vch Verlag gmbh and co. 3-527-30813-X . **Gundertofte, K. and Jorgensen, F.S.** (2000). Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers.	

	Mount, David. (2004). Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press. **Rastogi, S.C., Mediratta, N. and Rastogi. P.** 4th ed (2013). Bioinformatics, methods and applications, genomics, proteomics, and drug discovery, Prentice Hall of India, Pvt. Ltd., New Delhi. **Solomon K.**A. (2011). Molecular Modelling and Drug Design. MJ publisher. **Stephen Misener and Stephen Krawetz.** (2004). Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint **Webster, D. M. Ed.** (2000). Protein structure prediction: methods and protocols, Totowa Humana Press. **Public domain database/tools/resources** • DBGET-http://www.genome.jp/dbget/ • LinkDB-http://www.genome.jp/dbget/linkdb.html Fgeneshttp://www.softberry.com/berry.phtml?topic=products GeneBuilder-http://www.itb.cnr.it/sun/webgene/ • GeneSCAN-http://genes.mit.edu/GENSCAN.html • GRAIL-http://compbio.ornl.gov/Grail-1.3/ • CLC Free Workbench http://www.clcbio.com/index.php?id=28 BioEditor-http://bioeditor.sdsc.edu/ • CN3D 4.1 - http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml Protein Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm • Chimera-http://www.cgl.ucsf.edu/chimera/ • Yasara-http://www.yasara.comhttp://www.yasara.com) • Ribosome builder-http://rbuilder.sourceforge.net/ • ArrayExpress-www.ebi.ac.uk/arrayexpress/ • EPICLUST-http://ep.ebi.ac.uk/EP/	
Learning Outcomes:	1. Will enable to work with computational tools and to gain practical knowledge. 2. Will enable to analyze Next Generation Sequencing (NGS) raw data. 3. Will help to be better equipped to investigate specific contemporary biological questions.	

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Generic Elective Courses
Name of the Programme: M. Sc (Botany)
Course Code: BOT-621
Title of the Course: Introduction to Omics
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of the genome structure, genes, structure of proteins, and metabolism.	
Objective(s):	To familiarize students with terminology, underlying principles, and methodology in genomics, transcriptomics, proteomics, and metabolomics.	
Content:	1. **Genomics:** Classical genomics, Mendelian Genetics, Forward/Reverse Genetics, Linking Genotype and phenotypes, use and screening of mutants. Large Scale Genomic Sequencing: Platforms for Next Generation Sequencing (NGS), Second and third-generation sequencing, whole genome sequencing, targeted sequencing, Chromatin Immunoprecipitation (ChIP) sequencing, Applications of Genome sequencing and analysis. Epigenomics: Epigenome and Epigenetic regulation in Plants, Epigenetic modifications and their implications, D.N.A. methylation, Histone modification, Plant Mediator Complex, Epigenomic analysis. 2. **Transcriptomics:** Differential expression, Alternate splicing, R.N.A. sequencing and analysis, cDNA microarray analysis, ENCODE (Encyclopedia of D.N.A. elements) project. 3. **Proteomics:** Protein structure and function, amino acids, peptides, protein synthesis. Post-translational modifications of proteins: Glycosylation, Phosphorylation, Acetylation, Methylation, Ubiquitinylation, Sumolyation, Identification of post-translational modification in proteins, protein phosphorylation assay. Protein transport and Secretion, Protein targeting and trafficking, ER Golgi dynamics in protein sorting, dynamics of the membrane-bound protein, mechanism of protein secretion. Protein degradation: Ubiquitin-proteosome pathway, Lysosomal Proteolysis, role of autophagy and vesicular trafficking in protein degradation. Essentials of Protein-protein interaction: Protein interacting motifs, multi-protein complex, application of protein interactions, databases, and tools to study protein interactome. Protein Networks in Plant signalling: Introduction to plant signalling, types of membrane receptors (Membrane receptors, intracellular and extracellular receptors, G-protein coupled receptors, ion channels, Pattern recognition receptors), components of cell signalling (secondary messengers, sensors and effectors, Two-component system, signal perception), Types of signalling pathways, reversible phosphorylation and	**11 hours** **4 hours** **20 hours**

	dephosphorylation, role of plant signalling in development and immunity, Proteomic analysis, Techniques in proteomics and analysis: 2D electrophoresis, MS-ESI, MALDI-TOF, Protein Microarray. 4. **Metabolomics:** Overview of Metabolites, basics of metabolic pathways, errors of metabolism, sample preparation, extraction, derivatization, Targeted v/s untargeted metabolomics, Identification of molecular features and metabolites, structural confirmation, application of metabolomics in diagnosis. 5. **Metagenomics and Metatranscriptomics:** Introduction and overview, Sample harvesting, preparation, R.N.A. extraction, sequencing strategies, and data analysis.	**7 hours** **3 hours**
Pedagogy:	Lectures/Tutorials/Seminars/Assignments	
References/ Readings:	**António, C.** (2018) Plant Metabolomics- Methods and Protocols, Humana press, Hertfordshire, U.K. **Bernot A.** (2004) Genome, Transcripyome and Proteome Analysis. John Wiley. **Cooper, G.M.** (2000) The Cell: A Molecular Approach. 2nd edition. Sunderland (M.A.): Sinauer Associates, U.K. **Karp, G.** (2009) Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons, U.S.A. **Kramer, I. M.** (2015) Signal Transduction, 3rd edition, University of Bordeaux, Talence, France. **Lesk A.M.** (2015). Introduction to Genomics. Oxward University Press, India. **Nelson, D.L., Cox, M.M., and Lehninger, A.L.** (2013) Principles of biochemistry (p. 245), Freeman, New York. **Primrose, S.B. and Twyman, R.M.** (2006) Principles of gene manipulation and genomics, Blackwell Publishing, Australia. **Reece, R.J.** (2004) Analysis of genes and genomes. John Wiley & Sons Ltd. **Saraswathy, N. and Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. **Segev, N.** (2009) Trafficking Inside Cells, Springer science Business media, U.S.A. **Sessa, G.** (2012) Molecular Plant Immunity. John Wiley & Sons, Inc, Isarel. **Voet, D., Voet, J.G. and Pratt, C.W.** (2016) Fundamentals of biochemistry: life at the molecular level. John Wiley & Sons, U.S.A. **Walker, J.M. and Rapley, R.** (2008) Molecular Biomethods	

	Handbook, Hertfordshire, U.K. **Wilson, K. and Walker, J.** (2010) Principles and techniques of biochemistry and molecular biology, 7th edition. Cambridge University Press, U.K.	
Learning Outcomes:	1. Will familiarize students with principles and applications in Genomics, Transcriptomics, Proteomics, Metabolomics, Metagenomics, and Metatranscriptomics. 2. Will enable them to apply basic concepts in research.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-622
Title of the Course: Plant-Animal Interactions.
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Basic degree in biology.	
Objective(s):	To bridge the gap between various branches of Biological Sciences. To enable its application in Biodiversity, Conservation, Pollination, Crop productivity, Biological control, and Bioprospecting.	
Content:	1. **Diversity and Plant-Animal interactions:** Mutualism, Antagonism, Commensalism, Competition, Multi-trophic level interactions; Species interactions and the evolution of biodiversity; Co-evolution and co-speciation of plants and animals; adaptive radiation; the evolutionary history of interactions and evidence in the geological past; the principle of allocation. 2. **Pollination Biology:** Importance of cross-pollination. Evolutionary origin and early diversification of animal pollination; Special differentiation associated with pollinator attraction – advertisement and reward (pollen, nectar, elaiophores, resin glands, osmophores, optical displays, and visual clues). Floral adaptation to different pollinators, insect visitors (Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera), birds, bats, and non-flying animals. Sapromyiophily, brood-site pollination; fig-wasp interaction and pollination. Pollination Biology and gene flow: Foraging theory, foraging strategies, and time-niche strategies. 3. **Fruits, Seeds and Dispersal agents:** Plant adaptations – Fruit chemistry (chemical compartmentalization – pulp and seed, nutritional aspect of pulp, palatability inhibitors and toxins). The seed coat, seed toxins. Phenology; signals, fruit size, and fruit production. Dispersers: range of seed dispersers, seed shadow, frugivores as foragers: seed predators. Animal adaptations – External and internal morphology, digestive physiology, behaviour. Factors limiting recal plant and animal specializations. 4. **Herbivores and green plants:** Nutritional requirements of insects, seasonal and temporal distribution of nutrients in plant parts; Co-evolutionary arms race – plant defence and animal response; plant defence against herbivores – physical, chemical and 'third party' defences; animal responses – behaviour, detoxification, conjugation, target-site insensitivity, excretion. Herbivory v/s plant fitness. Herbivore efficiency and ecosystem dynamics, Effect of herbivores on plant	**7 Hours** **10 Hours** **8 Hours** **13 Hours**

	communities – The Janzen-Connell hypothesis. Effect of herbivores on plant communities. Hormonal interaction between plants and animals; hormone signalling in trophic interactions; animal pheromones and defense substances. 5. **Ant-plant interactions:** The origin and early evolution. Ant-plant symbioses – mutualism and non-mutualism (herbivores, harvesting ants, granivores, and leaf-cutting). Ants as primary and secondary seed dispersers; pollination by ants; direct and indirect association with plants; ant-fed plants and ant gardens; canopy ants; effects of harvesters on vegetation. Temporal and spatial variation in ant-plant interactions. Fungus growers. 6. **Carnivorous plants:** Mechanisms of interaction between carnivorous plants and animals, trap mechanisms, nutritional benefits of carnivory; cost-benefit analysis. Evolutionary pathways to carnivory. 7. **Plant communities as animal habitats:** Adaptations, ecological segregation within and between habitats; mechanisms of habitat selection, habitat selection theory, characteristics of plant resources and animal population dynamics, effects of plants on animal spacing and aggression. Animal diversity in relation to plant resource characteristics. Impact of invasive plants on native plant-animal interactions. Plant-animal interactions in agricultural ecosystems. Conservation aspects of plant-animal interactions. 8. **Climate change and breakdown of plant-animal interaction:** Impact on community, diversity, productivity, and livelihood.	**7 Hours** **4 Hours** **8 Hours** **3 Hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Field observations	
References/ Readings:	**Abrahamson, W.G.** (ed.). (1989). Plant-animal interactions. McGraw-Hill Book Company, NY. **Burslem, D., M. Pinard and S. Hartley. (**2005). Biotic Interactions in the Tropics: Their Role in the Maintenance of Species Diversity. Cambridge University Press. **Crawley, M.J.** (1986). Plant Ecology. Blackwell Scientific Publications. **Del-Claro, K. and Torezan-Silingardi, H.M.** (2021). Plant-animal interactions. Springer International Publishing, Switzerland. **Del-Claro, K. and Torezan-Silingardi, H.M.** (2021). An evolutionary perspective on plant-animal interactions. In *Plant-animal interactions* (pp. 1-15). Springer, Cham. **Endress, P.K. (**1994). Diversity and Evolutionary biology of tropical flowers. Cambridge University Press. **Harborne, J. B. (**1988). Introduction to ecological biochemistry. Academic Press. **Herrera, Carlos M. and Olle Pellmyr** (eds.). (2002). Plant Animal	

	Interactions: An Evolutionary Approach. Blackwell Science. **Holldobler, B. and Wilson, E.O. (**1990). The Ants. Springer-Verlag. **Keshamma, E., and Lokare, P.** (2022). Plant Animal Interaction. Book Saga Publications, US. **Lloyd, D.G. and Barret, S.C.H. (**1996). Floral Biology: Studies on Floral evolution in Animal pollinated plants. Chapman and Hall. **Price, P.W., T.M. Lewinsohn, G.W. Fernandes and W.W. Benson. (**1991). Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. A Wiley-Interscience publication **Proctor, M., Yeo, P. and Lack, A.** (1996). The Natural History of Pollination. Harper Collins Publishers. **Richards, A.J. (**1986). Plant Breeding systems. George Allen and Unwin, London. **Schaefer, M.H. and G.D. Ruxton.** (2011). Plant-Animal Communication. Oxford University Press. **Seckbach, J. and Z. Dubinsky.** (2010). All Flesh Is Grass: Plant-Animal Interrelationships. Springer Science and Business Media. **Simberloff, D.** (2022). Concise, comprehensive reviews of how invasive plants interact with plants, animals, and microbes. Biological invasions, Springer. **Smith, R.L.** (1990). Ecology and field biology. Harper and Row Publishers, New York. **Waser, N.M. and J. Ollerton.** (2006). Plant-Pollinator Interactions: From Specialization to Generalization. University of Chicago Press. **Whitmore, T.C.** (1990). An introduction to tropical rain forests. Clarendon Press, Oxford. **Willmer, Pat.** (2011). Pollination and Floral Ecology. Princeton University Press.	
Learning Outcomes:	1. Will enable the understanding of intricate evolutionary relationships between plants and animals, including their interdependence. 2. Will enable to understand the role of herbivory in phytochemical evolution and its importance in plant-based drugs. 3. Will enable to understand the importance of multicultural practices in controlling pests, organic farming, and reducing chemical pesticides. 4. Will enable to appreciate the ecosystem services through plant-animal interactions. 5. Will enable to understand the effect of climate change on plant-animal interactions, conservation, and survival of the human species.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-623
Title of the Course: Ecotourism.
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge in General Biology.	
Objective(s):	To create self-employment opportunities. To create awareness towards the conservation of natural resources. To help the students assess various ecotourism programmes.	
Content:	1. **Tourism and Eco-tourism:** Definition, concepts & components, Historical development, forms of tourism (inbound, outbound, domestic & international), Motivation for travel, measuring tourism demand, organizartions in tourism, impacts of tourisms, factors affecting future of tourism business. Sociology of tourism, relevance of ecotourism.	**3 hours**
	2. **Key Principles and Characteristics of Ecotourism**: Nature area focus, interpretation, environmental sustainability practices, contribution to conservation, benefiting local communities, cultural respect, customer satisfaction, responsible marketing.	**2 hours**
	3. **Components of Ecotourism:** Travel, tourism industry, biodiversity, local people, cultural diversity, resources, environmental awareness, interpretation, stakeholders, capacity building in ecotourism.	**2 hours**
	4. **Eco Tourism Terms**: Adventure tourism, certification, commercialization chain, cultural tourism, canopy walkway, conservation enterprises, ecosystem, ecotourism activities, ecotourism product, ecotourism resources, ecotourism services, endemism, ecolabelling, ecotourism "lite", Geotourism, greenwashing, stakeholders, sustainable development, sustainable tourism, leakages.	**5 hours**
	5. **Ecotourism resources in India and Goa**: Major ecosystems, vegetation types, biodiversity, and tourism areas in Goa. Ecotourism related festivals and events, entertainment overview, culture, famous destinations, sightseeing, historical monuments, museums, temples, national parks and wildlife sanctuaries, hill stations, waterfalls, rivers, lakes, beaches, islands, mangroves, backwaters, wildlife watching and bird watching sites, rural handicrafts, tribal medicines, archeological sites, adventure sports, sacred groves, mountains, etc.	**6 hours**
	6. **Forms of Ecotourism in India and Goa**: Eco regions, Eco places, Western Ghats of Goa, Waterfalls in Goa and India, Eco travel: do's and don'ts, Eco trips. Potentials of ecotourism in Goa. Community-based ecotourism.	**5 hours**

	7. **Ecotourism Planning**: Background, objectives, strategy, design of activities, target groups, opportunities, capacity building, threats, expectations of positive and negative impacts, strengths and weakness, benefits and beneficiaries, stakeholders, linkages, economics, ecotourism auditing. Problems with ecotourism. Carrying capacity of ecotourism. Ecotourism facilities – Green report card. Ecotourism management – issues. 8. **Ecotourism and livelihood security:** Community, biodiversity conservation and development – Eco-development committees.	**4 hours** **3 hours**
Pedagogy:	Lectures/Tutorials/Videos/Films/Group Discussion/ Expert Lectures/Assignments.	
References/ Readings:	**Batta, A.** (2000). Tourism and environment. Indus Publishing Co., New Delhi. **Bhattacharya, A.K.** (2005). Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **Cater, E.** (1994). Ecotourism in the third world: Problems and prospects for sustainability. **Cater and G. Lowman** Ecotourism: a sustainable option, Wiley, Chichester. **Croall, J.** (1995). Preserve or Destroy: Tourism and Environment, Calouste Gulbenkian Foundation, London. **Fennell, D.A.** (2014). Ecotourism. Routledge, CABI publishing, New York, USA. **Kumar, P**. Eco Tourism in India–An Overview (2015). Abhinav-International Monthly Refereed Journal Of Research In Management & Technology. **Kreg Lindberg, Deonal E. and Hawkins.** (1999). Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun. **Nekhvyadovich, L. I., Kuttubaeva, T. A., and Petrenko, N. E.** (2022). Ecotourism as a Basis for Sustainable Regional Development. In Geo-Economy of the Future (pp. 307-314). Springer. **Sathe, S. S. and Manepatil, U. R.** (2013). Studies on ecotourism potential of Sangli district: Case analysis with reference to places of botanical interest. **Varghese, A., Oommen, M. A., Paul, M. M., & Nath, S.** (Eds.). (2022). Conservation through Sustainable Use: Lessons from India. Taylor & Francis.	
Learning Outcomes:	1. Will enable to work in the ecotourism industry as an ecotourism guide or tour operator, as ecotourism planner or consultant. 2. Will enable to produce documentaries and movies in ecotourism.	

Name of the Programme: M. Sc (Botany)
Course Code: BOT-624
Title of the Course: Lab in Ecotourism.
Number of Credits: 2 (60 hours)
Effective from AY: 2022-22

Prerequisites for the course:	Basic knowledge of Biology. Students should opt for **BOT-602**.	
Objective(s):	To impart training in ecotourism-based goods and services to create trained human resources for ecotourism projects in Goa in particular and Western Ghats. To impart practical knowledge as short-term apprentices in ecotourism industry.	
Content:	1. Familiarizing with Ecotourism websites and portals. 2. Ecotourism films and documentaries - appreciation. 3. Production of ecotourism photo portfolio. 4. Production and display of original thematic video film of short duration. 5. Creation of an ecotourism-themed blog or website. 6. Creating artistic ecotourism promotional brochures, booklets, or posters. 7. Submission of ecotourism project proposal in a standard format. **Internship** 1. Pre-Internship work 2. Internship at assigned ecotourism facility 3. Preparation of terminal report	**4 hours** **4 hours** **4 hours** **8 hours** **4 hours** **4 hours** **4 hours** **4 hours** **20 hours** **4 hours**
Pedagogy:	Mini Projects, Hands-on training, Demos, Portal and Blog Design, Photographic and videography sessions, Field visits, Expert lectures, Videos, Apprenticeship at Ecotourism Facility.	
References/ Readings:	**Batta, A.** (2000). Tourism and Environment. Indus Publishing Co., New Delhi. **Bhattacharya, A.K.** (2005). Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **Cardoso, A. F. S., Sousa, B. B., and da Cunha, A. C. G.** (2022). Mobile Applications in Urban Ecotourism: Promoting Digitization and Competitive Differentiation. In Integrated Business Models in the Digital Age (pp. 349-369). Palgrave Macmillan. **Cater, E.** (1994). Ecotourism in the third world: Problems and prospects for sustainability. **Cater and G. Lowman** (1994)). Ecotourism: a sustainable option, Wiley, Chichester. **Croall, J.** (1995). Preserve or Destroy: Tourism and Environment, Calouste Gulbenkian Foundation, London. **Fennell, D.A.** (2014). Ecotourism. Routledge, CABI publishing,	

	New York, USA. **Kreg Lindberg, Deonal E. and Hawkins.** (1999). Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun.	
Learning Outcomes:	1. Will enable job prospects in ecotourism industry. 2. Will enable to launch ecotourism projects. 3. Will enable to work as ecotourism guides. 4. Will allow the preparation of market survey reports or consultancy reports on ecotourism. 5. Will help to develop the ability to contribute to framing ecotourism policies and strategies. 6. Will provide better prospects to work as a travel writer, food columnist, etc. 7. Will offer a better capacity to produce documentaries and photographs on ecotourism destinations.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-625
Title of the Course: Mushroom Biotechnology
Number of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Biology.	
Objective(s):	To impart knowledge in the diversity and biology of mushrooms. To acquire knowledge of mushroom biotechnology concerning edible and medicinal species. To acquire information on toxic species of mushrooms. To gain knowledge on mushroom production and marketing.	
Content:	1. Cultivation Technology: Infrastructure, equipment, and substrates in mushroom cultivation. 2. Diversity of mushrooms, edible and medicinal mushrooms, criteria for edibility, domestication of edible and medicinal mushrooms. 3. Mushroom biotechnology of commercially cultivated species. 4. Spawn development and quality parameters. 5. Production and quality management. Substrates used in mushroom production. 6. Harvesting, grading, branding, marketing. 7. Mushrooms-post harvest processing and value addition. 8. Storage and food preparation from mushrooms. 9. Mushroom marketing, scope for new species, scope in tropical countries. 10. Future of mushroom industry-global, national, local perspectives.	**1 hour** **2 hours** **1 hour** **2 hours** **2 hours** **1 hour** **2 hours** **2 hours** **1 hour** **1 hour**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Videos/Moodle based guidance/Expert Lectures.	
References/ Readings:	**Board N.** (2006). Handbook on Mushroom Cultivation and Processing: With Dehydration, Preservation and Canning: Asia Pacific Business Press, 522 pp. **Biswas S., Datta M. and Ngachan S.V.** (2007). Mushrooms: A Manual for Cultivation: PHI Learning, 220 pp. **Chang, S.T. and W. A. Hayes** (2013). The Biology and Cultivation of Edible Mushrooms. Academic Press Inc., New York, New York. 819 pp. **Dutta, R.** (2007). Advances in mushroom science. Satish Serial Publishing House, Delhi. **Gogoi Robin, Rathaiah Yella and Borah Tasvina Rahman** (2006). Mushroom Cultivation Technology: Scientific, 130 pp. **Jana B.L.** (2014). Mushroom Culture: Agrotech Publishing Academy, 152 pp. **Kannaiyan S., Marimuthu T. and Lenin K.** (Ed) (2011), Diversity and Production of Edible Mushrooms: Associated Publishing Company, 184 pp.	

	Kuo, M. (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp. **Kumar, A., and Satpathy, A.** (2022). Cultivation of Two Edible Mushrooms and Need for Training of Mushroom Production Technology to Enhance Rural Economy. In Biology, Cultivation and Applications of Mushrooms (pp. 561-577). Springer, Singapore. **Largent, D.L., Johnson, D. and Watling, R.** (1973). How to identify mushrooms to genus III: Microscopic features. Eureka, CA: Mad River Press. 148 pp. **Largent, D.L. and Baroni, T.J.** (1988). How to identify mushrooms to genus VI: Modern genera. Eureka, CA: Mad River Press. 277 pp. **Moser, M.** (1983). Keys to Agarics and Boleti (Polyporales, Boletales, Agaricales, Russulales). Ed. Kibby, G. Transl. Plant, S. London: Roger Phillips. 535 pp. **Pacific Northwest Key Council** (2006). Keys to mushrooms of the Pacific Northwest. Retrieved from the Pacific Northwest Key Council. **Pathak V.N., Yadav Nagendra and Gaur Maneesha** (2011). Mushroom Production and Processing Technology: Agrobios, 180 pp.**Phillips, R.** (1991). Mushrooms of North America. Boston: Little, Brown and Company. 319 pp. **Ram Aavishkar R.C.** (2007). Mushrooms and Their Cultivation Techniques. 164 pp. **Roberts, P. and Evans, S.** (2014). The Book of Fungi: A Life-Size Guide to Six Hundred Species from Around the World. United Kingdom: Ivy Press. **Singh J.K.** (2012). Mushroom: Diseases and Its Control: Enkay Pub, 264 pp. **Singh Reeti and Singh U.C.** (2011). Modern Mushroom Cultivation: Agrobios, 229. **Singh S.K. and Jha P.K.** (2014). Mushroom: Production and Utilization: Scientific Publishers, 2014, 189 pp. **Suman B.C. and Sharma V.P.** (2014). Mushroom Cultivation in India: Daya, Reprint, 180 pp. **Verma B.N., Prasad Prem Kumar and Sahu K.K.** (2013). Mushrooms: Edible and Medicinal Cultivation Conservation Strain Improvement with their Marketing: Daya, 431 pp.	
<u>Learning Outcomes:</u>	1. Will enable to appreciate the ethnomycological traditions and role of edible mushrooms in culture and economy. 2. Will enable to handle and culture edible mushrooms independently. 3. Will enable the analysis of mushroom production and marketing trends. 4. Will enable to work in the mushroom industry.	

Name of the Programme: M. Sc (Botany)
Course Code: BOT-626
Title of the Course: Lab in Mushroom Biotechnology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of biology. Students should opt for **BOT-604**.	
Objectives:	To impart training in the production, quality evaluation, and marketing of edible mushrooms and their nutritional importance.	
Content:	1. Identification of mushroom habitats. 2. Identification of edible, medicinal, and toxic mushroom species. 3. Preparation of culture, preparation of mother spawn, and multiplication. 4. Obtaining and studying mushroom spore prints. 5. Developmental biology of local wild mushrooms. 6. Preparation of pure mushroom cultures. 7. Production of S.C.P.s (single cell proteins) from submerged culture of edible mushrooms. 8. Production and evaluation of mushroom spawn. 9. Processing and preservation of mushrooms, economics of spawn, and mushroom production. 10. Oyster mushroom cultivation using tissue paper rolls and any other substrate. 11. Mushroom quality evaluation- button or oyster mushrooms. 12. Visit to a mushroom industry and submission of report.	**2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Practical Exercises, Hands-on training, Videos, Moodle-based guidance.	
References/ Readings:	**Arora, D.** (1986). Mushrooms demystified: A comprehensive guide to the fleshy fungi. Berkeley: Ten Speed Press. 959 pp. **Kuo, M.** (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp. **Kuo, M. and A. Methven** (2010). 100 Cool Mushrooms. Ann Arbor: University of Michigan Press. 210 pp. **Kumar, A., and Satpathy, A.** (2022). Cultivation of Two Edible Mushrooms and Need for Training of Mushroom Production Technology to Enhance Rural Economy. In: Biology, Cultivation and Applications of Mushrooms (pp. 561-577). Springer, Singapore. **Largent, D. L.** (1973). How to identify mushrooms to genus I: Macroscopic features. Eureka, CA: Mad River Press. 86 pp. **Largent, D. L. and Thiers, H. D.** (1973). How to identify mushrooms to genus II: Field identification of genera. Eureka, CA: Mad River Press. 32 pp.	
Learning Outcomes:	1. Will enable the cultivation of edible mushrooms and produce quality mushroom spawn. 2. Prospects to work in a mushroom industry.	

	3. Will enable the preparation of consultancy reports on mushroom production and marketing. 4. Will enable to work as a master trainer in mushroom cultivation camps or workshops.	

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Name of the Programme: M. Sc Botany
Course Code: BOT-627
Title of the Course: Marine Phytoplanktons
No. of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of algae.	
Objective(s):	To impart training in the identification of microalgae. To impart knowledge in phytoplankton ecology. To impart knowledge on the economic importance of phytoplanktons.	
Content:	1. Taxonomic and Ecological Classification of Phytoplankton. Ecological Roles. 2. **Marine Diatoms**: General characteristics, Life cycle, Morphology, and terminology concerning centric and pennate diatoms Diatomite-industrial mineral, Calcareous algal fossils, and their products algal kerogen in petroleum and coal. 3. **Marine Dinoflagellates**: General characteristics, Morphology, and terminology, Microanatomy, Taxonomy, Bloom dynamics, and impacts: Initiation, Growth, Maintenance, and Termination. Ecological and Economic impacts: Negative and Positive impacts. Harmful algal blooms in India. 4. **Planktonic Microflagellates:** General characteristics, Morphology and terminology, Taxonomy of Chromophyta, Cryptophyta and Raphidophyta, Chrysophyta (Dictychophyceae, Prymnesiophyceae- Haptophyceae) Chlorophyta (Euglenophyta, Prasinonohyta and Chlorophtya). Coccolothophorids: Holococolithophorids and heterococcolithophorids. 5. **Marine biofouling**: Bacterial, Microalgal, and Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in Chemical control, Biological control, Non-adhesive surfaces. 6. Identification, Collection, preservation, and preparation techniques for the plankton groups.	**2 hours** **3 hours** **3 hours** **3 hours** **2 hours** **2 hours**
Pedagogy:	Lectures/Tutorials/Assignments.	
References/ Readings:	**Fritsch, F.E.** (1935). The Structure and Reproduction of the Algae. Cambridge University Press. **Hallegraeff, G.A**. (1993). A review of harmful algal blooms and their apparent global increase. Phycologia 32, 79-99. **Hallegraeff, G.M., Anderson, D.M. and Cembella, A.D.** (2003). Manual on Harmful Marine Micro-algae. UNESCO. **Hargraves, P.E., and French, F.W**. (1983). Diatom resting spores: Significance and strategies. In: Fryxell, G. A. (Ed.), Survival Strategies of the Algae. pp. 49-68. Cambridge: Cambridge University Press.	

	Reynolds C. S. (2014). The Ecology of Phytoplanktons, Cambridge University Press, New York. **Tomas, C.R.** (2012). Marine phytoplankton: a guide to naked flagellates and coccolithophorids. Academic Press, USA. **Williams, P.J.L.B., Thomas, D.N., & Reynolds, C.S. (Eds.).** (2008). Phytoplankton productivity: carbon assimilation in marine and freshwater ecosystems. John Wiley & Sons., New York, USA.	
Learning Outcomes:	1. Will enable to identify the marine microalgae. 2. Will help to work as an Assistant in Environmental Monitoring Programme.	

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Name of the Programme: M. Sc. (Botany)
Course Code: BOT-628
Title of the Course: Oenology
Number of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of biology.	
Objective(s):	To understand the basics of oenology. To understand the origin, history, and concept of wine tasting. To impart training on small-scale fruit wine production.	
Content:	1. Overview of Oenology, ancient and modern methods of winemaking. 2. Viticulture and Grape species. 3. Wine Types and Styles, Wine Regions and Terroir, the Indian wine scene. 4. Harvesting and processing of grapes and other fruits. 5. Sources of contamination in winemaking; Sanitation and Sterilization. 6. Scales of winemaking, micro-vinification, Materials, and supplies used in winemaking. 7. Chemistry and cell biology of fermentations with yeast and bacteria. 8. Fermentation processes; Post-fermentation. 9. Wine analysis; Chemical components of Wine; Biochemical reactions in fermentation. Winery by-products and their management. 10. Wine acids, Aroma compounds (Terpenes), colour and flavour compounds (phenolics, Tannins). 11. Sensory evaluation and quality control in winemaking. 12. Wine microbial spoilage and its control; Wine defects and remedies. 13. Wine bottling, corking, packaging, branding, and marketing strategies. 14. Alcohol marketing laws (India and Worldwide); Revenue system in Goa and other States. 15. Alcohol regulatory policies; State excise policies in Goa and other States.	**1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Videos/Expert-Lectures/Industrial visits/Moodle based guidance.	
References/ Readings:	**Amerine, M.A., Berg, H.W., Kunkee, R.E., Ough, C.S., Singleton, V.L. and Webb, A.D.** (1980). The Technology of Winemaking. 4th edition. A.V.I. Publishing Co. Inc. Westport. **Amerine, M.A. and Roessler, E.B.** (1983). Wines: Their sensory	

evaluation. WH Freeman & Co. San Francisco.

Amerine, M.A., and Singleton, V.L. (1977). Wine: An Introduction to the Wines of the World, Grape Cultivation, Techniques of Wine-making, and how to evaluate and Enjoy Wines. University of California Press.

Fleet, G.H. (1993). Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur.

Fugelsang, K.C. (1997). Wine Microbiology. Chapman & Hall, New York.

Jackson, R.S. (2000). Wine Science: Principles, Practice, Perception. Second Edition. Academic Press, Inc., 525 B Street, Suite 1900, San Deigo, California.

Jordão, A.M., and Cosme, F. (2022). The Application of Wood Species in Enology: Chemical Wood Composition and Effect on Wine Quality. Applied Sciences, 12(6), 3179.

Linskens, H. F. and Jackson, J.F. (1988). Wine Analysis: Modern Methods of Plant Analysis. New series volume 6. Springer Verlag.

Ough, C.S. (1991). Winemaking Basics. Food Products Press, New York.

Ribereau-Gayon, P., Dubourdieu, D. and Doneche, B.A. Lonvaud. (2000). Handbook of Enology Volume 1: Microbiology of Wine and Vinifications. John Wiley and Sons, New York.

Ribereau-Gayon, P., Glories, Y.A. Maugean and Dubourdieu, D. (2021). Handbook of Enology Volume 2: Microbiology of Wine, The Chemistry of Wine Stabilization and Treatments. John Wiley and Sons, New York.

Schahinger, G. and Rankine, B. (1992). Cooperage for Winemakers: A manual on the construction, maintenance, and use of oak barrels. Ryan Publications, Adelaide, South Australia.

Storm, D.R. (1997). Winery utilities: planning, design and operation. Chapman and Hall, New York.

Vine, R.P. (1981). Commercial Winemaking, Processing and Controls. A.V.I. Publishing Co., Westport, CT.

Vine, R.P., Harkness E.M., Browning, T., Wagner, C. and Bordelon, B. (1997). Winemaking: from grape growing to marketplace. Chapman and Hall, New York.

Waterhouse, A.L. and Ebeler, S.E. (1998). Chemistry of Wine Flavor. American Chemical Society, Washington, D.C.

Yendell, K. (2015). Winemaking: Fermenting, Pressing, Bottling, and Aging: An Introduction to Oenology. United States: CreateSpace Independent Publishing Platform.

Enological websites

	• Academic study of winemaking from the University of California, Davis http://www.wineserver.ucdavis.edu • Web site for American journal of oenology and viticulture. http://www.ajevonline.org • Internet journal of viticulture and oenology http://www.infowine.com	
Learning Outcomes:	1. Will enable to understand international trends in the production and marketing of wines and to define a terroir. 2. Will enable to appreciate the role of wine in culture, religion, industry, and economy. 3. Will enable to assist in the wine industry. 4. Will provide better prospects in the tourism industry.	

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Name of the Programme: M. Sc. (Botany)
Course Code: BOT-629
Title of the Course: Lab in Oenology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Biology. Students should opt for BOTG-506.	
Objective(s):	To make students employable as oenologists.	
Content:	1. Identification of different winemaking equipment. 2. Culture and examination of different yeast strains used for winemaking. 3. Microscale production of grape wine. 4. Monitoring of fermentation parameters of grape wine using a refractometer and hydrometer. 5. The organization of wine evaluation: the space, equipment, temperature, order of serving the wines. 6. Benchtop production and monitoring of wines from fruits, spices, and condiments. 7. Organosensory evaluation of grape and other fruit wines. 8. Analysis of alcohol content in wine. 9. Analytical testing in winemaking (Reducing sugars, pH, Acidity, Ammonia nitrogen, Sulphur dioxide, Turbidity, Dissolved oxygen). 10. Report on wine brands and wine marketing.	**1 hours** **2 hours** **4 hours** **4 hours** **2 hours** **8 hours** **2 hours** **2 hours** **3 hours** **2 hours**
Pedagogy:	Lab exercises/Demos/Field visits/Industrial visits/Expert Lectures/Videos.	
References/ Readings:	**Boulton, R. B., Singleton, V. L., Bisson, L. F. and Kunkee, R. E.** (1996). Principles and Practices of Winemaking. Chapman and Hall, New York. **Fleet, G. H.** (1993). Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur. **Fugelsang, K. C.** (1997). Wine Microbiology. Chapman and Hall, New York. **Iland, P, Ewart, A. and Sitters, J.** (1993). Techniques For Chemical Analysis and Stability Tests of Grape Juice and Wine. Patrick Iland Wine Promotions, P.O. Box 131, Campbelltown, South Australia 5074. **Iland, P.** (1991). An Introduction to Wine: A Guide to the Making, Tasting, and Appreciation of Wine. Patrick Iland Wine Promotions, P.O. Box 131, Campbelltown, South Australia 5074. **Pougnet, S., Martin-Rios, C., and Pasamar, S.** (2022). Keg wine technology as a service innovation for sustainability in the	

	food service industry. Journal of Cleaner Production, 132145. **Tsegay, Z. T., Sathyanarayana, C. B., and Lemma, S. M.** (2018). Optimization of cactus pear fruit fermentation process for wine production. Foods, 7(8), 121. **Tsegay, Z. T., and Gebremedhin, K. M.** (2019). Physicochemical and sensory properties of wine produced from blended Cactus Pear (*Opuntia ficus-indica*) and *Lantana camara* Fruits. Journal of Food Quality. **Velchev** (2017) Wine Informatics: A quantitative analysis of wine reviewers https://uca.edu/cse/files/2020/02/Wineinformatics-A-Quantitative-Analysis-of-Wine-Reviewers.pdf	
Learning Outcomes:	Will provide the ability to produce fruit wines on a small scale; develop expertise to carry out the sensory evaluation of wines; work as a trainee oenologist, wine journalist, or columnist; join the hospitality sector as an expert on elite brands of wines.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-630
Title of the Course: Ethnobotany
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	To impart knowledge in ethnobotany, methods of collecting ethnobotanical data, and commercial use of traditional knowledge.	
Content:	1. Introduction: Brief history of ethnobotanical studies in the world and India; Scope of ethnobotany. Subdisciplines of ethnobotany. Interdisciplinary approaches. Knowledge of sociological and anthropological terms. 2. Distribution of tribes in India. Knowledge of tribes of Konkan, Goa, and Kanara; Ethnobotanical work on these tribes. 3. Sources of ethnobotanical data: Primary - archaeological sources and inventories, Secondary - travelogues, folklore and literary sources, herbaria, medicinal texts, and official records. Methods in ethnobotanical research. Research design and cautions in data collections, Practical and field skills; Prior informed consent, Participatory Rural Appraisal (P.R.A.) techniques, interviews and questionnaire methods, choice of resource persons. 4. Ethnobotanical knowledge and communities: Ethnobotanical classification; Folk taxonomy of plants. Non-Timber Forest Produce (NTFP) and livelihood. Sustainable harvest and value addition. Ethno-mycology. Conservation and community development. 5. Bioprospecting and commercial use of traditional knowledge; Medical ethnobotany, ethno-pharmacology and the search of plant-based drugs. Developing research partnerships: Ethics and research guidelines in ethnobotany, equitable research relationships. 6. Traditional knowledge (T.K.) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit sharing models of the world. 7. Ethnobotany and People's Biodiversity Register (P.B.R.). Practical applications of ethnobotanical data; Ethno-medicine and primary health care; Ethnobotany and ethno-pharmacology as a tool to protect interests of ethnic groups and rural development.	**5 hours** **5 hours** **5 hours** **5 hours** **5 hours** **3 hours** **2 hours**
Pedagogy:	Lectures/ Tutorials/Assignments.	

References/ Readings:	**Alexiades, M. (**1996)**.** Selected guidelines for ethnobotanical research: A field manual. New York: New York Botanical Garden. **Apte, T. (**2006)**.** Intellectual Property Rights, Biodiversity and Traditional Knowledge. Kalpavriksh, Grain and IIED, Pune / New Delhi. **Balee W. L. (**2003). Footprints of the Forests. Bishen Singh Mahendar Pal Singh, Dehra Dun, India. **Balick, M. and P. A. Cox. (**1996). Plants, People, and Culture: The Science of Ethnobotany. Scientific American Library, New York. **Begossi, A. (**1996)**.** Use of ecological methods in ethnobotany. Economic Botany 50 (3): 280–89. **Chauhan, S., and Chauhan, S. V. S.** (2019). Worship and trees in India. Siberian Journal of Forest Science, 4: 36-48. **Cotton, C. M. (**1997). Ethnobotany – Principles and Applications. John Wiley and Sons Limited. New York, U.S.A. **CSIR. (**1940-1976). Wealth of India. A Dictionary of Raw Materials and Industrial Products - Raw Materials.Vol.1-11. CSIR Publication and Information Directorate. New Delhi. **Jain, A. K.** (2016). Indian ethnobotany: emerging trends. Scientific Publishers.	
Learning Outcomes:	1. Will enable students to understand the importance of traditional knowledge systems in ethnobotany important for GIP and the pharma industry. 2. Will enable better ability to interact with tribes and other medicinal practitioners and people having special knowledge of medicinal and other useful plants. 3. Will help develop a career with N.G.O.s involved in documenting tribal knowledge.	

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SEMESTER IV

Research Specific Elective Courses

Name of the Programme: M. Sc Botany

Course Code: BOT-606

Title of the Course: Research Methodology, Techniques, and Instrumentation

No. of Credits: 4

Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of computers, information technology, and biochemistry.	
Objective(s):	To impart training in literature survey, citations, scientific writing, experimental design, basic biostatistics, principles, and working of various instruments.	
Content:	1. **Literature survey**: Need for literature review; research reading and discriminative reading; bibliographic collection; literature citation; different system of citations, Journal abbreviations.	**3 hours**
	2. Computers and information technology in Research: Computer operating systems, search engines, e-journals, online publications, M.S. office, Webliography.	**3 hours**
	3. **Scientific Writing:** Basics and importance of scientific writing; clarity, language; scientific paper and proposal components, Title, Abstract, Introduction, Materials and Methods, Results and Discussion, Conclusion, References, Tables, and Illustrations; Research article, Review Paper, Book Chapter, Presentation, Scientific poster.	**3 hours**
	4. Use of Intellectual Property Rights to search IPR databaseas a tool for research, Patent databases: worldwide (Espacenet), country specific (Industrial property digital library, CIPO, SurflP), Non-Governmental databases, IPR in data management, Data Licensing and Ownership.	**4 hours**
	5. **Experimental Designs and Biostatistics:** Basic principles of experiment, Experimental unit, and sampling unit, Observation, Hypothesis, Experimental error, replicates, controls, randomization, null hypothesis; Population and sample, variables, data collection sampling methods, Significance, statistical test.	**4 hours**
	6. **Laboratory practices and safety in the laboratory**: Research Bioethics and Good Laboratory Practices, General safety measures, Chemical, Physical, and Biological hazards, spillage and waste disposal, disposal of radioactive waste, first aid, and Material Safety Datasheet (MSDS).	**2 hours**
	7. **pH and buffer solutions**: S.I. units; Molarity and Normality; Acids and bases; Hydrogen ion concentration and pH, Dissociation of acids and bases; Buffer solutions, reaction kinetics, and thermodynamics.	**4 hours**
	8. **Centrifugation Techniques**: Basic principles of sedimentation; Relative Centrifugal Force (R.C.F.) and gravitational (g) force,	

	Density gradient centrifugation; design and care of rotors, safety aspects in the use of centrifuges.	**3 hours**
	9. **Spectroscopic Techniques:** General principles; Radiation energy and atomic structure; Basic law of light absorption; Types of spectra and their biological usefulness. Principle, application, and instrumentation of UV-VIS spectrophotometry; I.R. (infra-red) spectrophotometry; Spectrofluorometry, Atomic absorption spectroscopy (A.A.S.) and flame photometry; Mass spectrometry.	**9 hours**
	10. **Chromatography Techniques**: General Principles, techniques, and applications: Materials for column chromatography, adsorption, partition, molecular sieving, ion exchange, and affinity chromatography. Factors influencing resolution. Column development – isocratic system and gradient solvent. Chromatogram reading, qualitative and quantitative determination of peaks.	**8 hours**
	11. **Electrophoresis Techniques**: General principles, Gel electrophoresis of nucleic acids and proteins, Native PAGE, Sodium Dodocyl Sulphate-Polyacrylamide Gel Electrophoresis (S.D.S.–PAGE), Isoelectric focusing and its application, 2D electrophoresis, Pulsed-field electrophoresis, Capillary electrophoresis, Blotting techniques: Detection, recovery, and estimation.	**7 hours**
	12. **Radiobiology**: The nature of radioactivity; Atomic structure, stability, and radiation; Isotopes; Types of radioactive decay; Detection and measurement of radioactivity; Applications of radioisotopes in biological sciences; Safety aspects for the use of radioisotopes. Non-radioactive labelling.	**2 hours**
	13. **Molecular techniques**: Flow Cytometry, Immuno-techniques, Fluorescence Resonance Energy Transfer (FRET), Fluorescence Recovery After Photobleaching (FRAP), Yeast hybrid assay, Immunoprecipitation assay, Surface Plasmon Resonance, Proximity labelling, Electrophoretic Mobility Shift Assay (EMSA), Footprinting, Protein Crystallography, Microarray analysis, Site-Directed Mutagenesis, Biosensors, Clustered Regularly Interspaced Short Palindromic Sequence/CRIPSR Associated Genes (CRISPR/Cas).	**8 hours**
Pedagogy:	Lecture/e-learning/Assignments/Seminars/Moodle.	
References/ Readings:	**Bailey P.L.** (1980). Analysis and ion selective electrodes 2nd Ed. Heyden, London. **Bates R.G.** (1973). Determination of pH: Theory and Practices, 2nd Ed. John Wiley, New York. **Bauman R.P.** (1981). Absorption Spectroscopy. John Wiley, New York **Becker R.S.** (1969). Theory and interpretation of fluorescence and phosphorescence, Wiley Interscience, New York.	

Bell R. J. (1973). Introductory Fourier Transform spectroscopy. Academic Press, New York.
Brech F. (1974). Analysis in instrumentation. Vol. 6. Plenum, New York.
Colthup N.B., Daly L.H. and Wiberley S.E. (1975). Introduction to Infra-red and Raman Spectroscopy 2nd Ed. Academic Press. New York.
Day, R.A. and Gastel, B. (2016). How to write and publish a scientific paper, Cambridge University Press.
Dean J. and Raina T. (1969). Flame emission and atomic absorption. Dekker, New York.
Dixon R.N. (1965). Spectroscopy and Structure. Mathuen, London
Giddings J.C. (2002). Principles and Theory, Dynamics of Chromatography Part I Dekker, New York.
Grob R.L. (2004). Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York.
Guilbault G.G. (Ed.) (2020). Practical Fluorescence. CRC Press.
Gurumani N. (2006). Research methodology for biological sciences. M.J.P. Publishers, Chennai.
Gurumani N. (2005). An Introduction to Biostatistics, M.J.P. Publishers, Chennai.
Hames B.D. and Rickwood D. (1998). Gel electrophoresis of Proteins: A practical approach 2nd ed. IRL Press, Oxford.
Hofmann A. and Clokie S. (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.
Jacob R., **Alexander D. Lane L.** (2018). A guidebook to Intellectual property:Patent, trademarks, copyrights and design. Sweet and Maxwell ltd, UK.
Karp, G. (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley and Sons, U.S.A.
Kolthoff I.M. and Elving P. J. (1978). Treatise on analytical Chemistry, Wiley Interscience, New York.
Myneni S.R. (2019). Patent Drafting and Specification Writing. New Era Law Publication, Hariyana.
Pesez M and Bartos J. (1974). Colorimetric and Fluorometric Analysis of Organic Compounds and drugs, Dekker, New York.
Reece, R. J. (2004). Analysis of genes and genomes. John Wiley and Sons Ltd.
Sacks R.D. (1981). Emission Spectroscopy. John Wiley, New York.
Saraswathy, N. and Ramalingam, P. (2011). Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York.
Sharma, B.K. (2006). Principal of analytical chemistry, Meerut Publication, Meerut.
Simpson C.F. (1979). Techniques in liquid chromatography, Wiley-Heyden, New York. Horvath C. HPLC Vol. I Academic Orlando.

	F.L. Fritz J.S., Gjerde D.T. and Pohlandt C. Ion chromatography, A. Huthig, Heidelberg **Walker, J. M., and Rapley, R.** (2008). Molecular Biomethods Handbook, Hertfordshire, U.K. **Watson I.N.** (1976). Introduction to Mass spectroscopy, Raven, New York. **Willard H.F., Merritt L.L., Dean, J.A. and Settle F.A.** (1988). Instrumental Method of analysis. C.B.S. Publishers and distribution, New Delhi **Williams D.R. and Mowthorpe D. J.** (1976). Nuclear Magnetic Resonance Spectroscopy. John Wiley, New York. **Yau W. W., Kirkland J.J. and Bly D.D.** (2009). Modern size exclusion chromatography, Wiley Interscience, New York.	
Learning Outcomes:	1. Will enable a better understanding of the primary research methodologies, instrumentation, and designs. 2. Will enable to gain comprehensive knowledge of proper scientific measuring and scaling approaches along with the theory of computational tools. 3. Will enable better analysis and interpret qualitative and quantitative data. 4. Will enable the investigation of specific biological questions. 5. Will enable to conceive knowledge about scientific writing and presentation of credible scientific reports.	

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Name of the Programme: M. Sc (Botany)
Course Code: BOT-607
Title of the Course: Applied Phycology: Utilization and Management
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of algae.	
Objective(s):	To impart knowledge on the commercial applications of Algae and their use in environmental management.	
Content:	1. **Mariculture:** Scientific basis and Techniques of Mariculture: *Eucheuma*, *Porphyra,* and *Laminaria* technique. Rafts used in Mariculture.	**5 hours**
	2. **Seaweed cultivation in India:** Seaweed resources and their distribution in India, Promotion of seaweeds in India, Seaweed cultivation and value chain in India. Seedling production of *Gracilaria* and *Ulva*.	**2 hours**
	3. **Food and food products from Seaweeds:** *Porphyra* as food: Cultivation and economics; Food and other uses, development of cultivation methods, present, and future trends. *Spirulina* as human food: Nutritional aspects. Economic and environmental aspects. Therapeutic applications, harvesting wild populations, Village scale production, Microalgal nutraceuticals, and their production; Cultivated edible kelps: Edible products, kelp composition, kelp production methods, and world production. Some public health aspects of microalgal products. Pheophorbide, Microbial contamination, Extraneous materials, metals, organic compounds, Maintaining sanitary quality.	**10 hours**
	4. **Commercial production and application of algae: *Hydrocolloids*:** History, Chemistry production, and Application, future aspects of alginates, Carrageenans, Agars. An overview of Agarophytes and Carragenanophytes in India. **Lipids and Polyols from microalgae**: History of microalgal lipid production research, Tri-glycerol, Hydrocarbon, carotenoids, polyols. **Hydrogen production by algae:** Water splitting role of algae in hydrogen production, principles of photosynthetic hydrogen production, Bio-photolysis of water. **Products from fossil algae:** Diatomite-industrial mineral, Calcareous algal fossils, and their products, algal kerogen in petroleum and coal. **Biodiesel from Microalgae:** Potential of Microalgal diesel, Micro-algal mass production (Raceway Pond and photobioreactors); Economics of microalgal biodiesel.	**14 hours**

	5. **Algae in Environmental Management:** **Algae and Agriculture:** Free-living cyanobacteria and algalization, *Azolla*, Microalgal soil conditioners, Microalgal plant growth regulation, Biopesticides. Use of seaweeds in agriculture and horticulture. **Microalgae in liquid waste treatment and reclamation:** Biological waste treatment system, Design consideration (Algal concentration, algal productivity), Operation of the integrated algal bacterial system, current application, future application (Sewage grown algae, energy system, toxin removal. **Phycoremediation:** Role of algae in Phytoremediation; Role of physico-chemical parameters on growth and development of algae; Algal survival and pollution: Algal survival under physical and chemical stresses; Responses of algae to pollutants and heavy metal pollution; Uptake and accumulation of xenobiotic substances; Utilization of algae in pollution control; Effluent treatment using algae; Algal biomass and its utilization; Algae as an energy source, Algal biofuels; Industrial collaborations.	**14 hours**
	6. **Harmful Aspects of Algae:** **Marine dinoflagellates blooms:** Dynamics and impacts; Bloom dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative and Positive impacts. Harmful algal blooms in India. **Hazards of freshwater blue-green algae*:*** (Cyanobacteria) Neurotoxins, Hepatotoxins, other toxins, Medicinal aspects; Human poisoning, contact dermatitis. **Marine biofouling*:*** Bacterial, Microalgal, and Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in chemical control Methodology, Biological control, Non-adhesive surfaces.	**9 hours**
	7. **Prospects of Algae:** **Algae in space:** Algae and life support systems; Algae and planetary biology, Future of algae in space. Algal Transgenics and Biotechnology. **Algae in Biotechnology:** Algae as a source of bioactive commercial pigments (chlorophylls, phycobilin, and carotenoids); Macro- and micro-algae in the field of Cosmeceuticals, Production of fatty acids (PUFA), vitamins, antioxidants from Algae; Algae as recombinant enzyme bio-factories, production of single cell proteins, Algal production and cultivation, Transgene expression in microalgae; Major algal-based companies in the world, Algal based commercial products in the market, Algal research laboratories across the globe; Use of synthetic biology in the manufacture of by-products from Algae. Bioplastics from seaweeds; Genetic	**6 hours**

	engineering and development of molecular markers.	
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Visit to Research Laboratories.	
References/ Readings:	**Ahmad, A., Banat, F. and amp; Al Blooshi, H. (eds.).** (2022). Algal Biotechnology: Integrated Algal Engineering for Bioenergy, Bioremediation, and Biomedical Applications. Elsevier. **Alexander, I. and Railkin** (2004). Marine biofouling: colonization processes and defenses. C.R.C. Press L.L.C. **Alexander, M.** (1999). Biodegradation and Bioremediation. Academic Press. **Ayhan Demirbas**. (2008). Biofuels: Securing the Planet's Future Energy Needs. Springer – Verlag London Limited. **Chapman, V. J., and Chapman**, D.J. (1975). The algae, 2nd Edition, Mac. Millan Publ. Inc. New York. **Craig A. Grimes., Oomman** (2008). Light, water, hydrogen: the solar generation of hydrogen by water. Springer Science + Business Media, L.L.C. **Crawford, R.L. and Crawford, D.** (1996). Bioremediation: Principles and Applications. Cambridge University Press, U.K. **David M. Mousdale** (2008). Biofuels: biotechnology, chemistry, and sustainable development. Taylor & Francis Group, L.L.C. **Dean, S. W., Guillermo Hernandez-Duque Delgadillo, James B. Bushman**. (2000). Marine corrosion in tropical environments. American Society for Testing and Materials. **Dey P.M., Jeffrey and B. Harborne** (1997). Plant Biochemistry, Academic Press. **Féron D.** (2001). Marine corrosion of stainless steels. Snippet view West Conshohocken. **Féron, D.** (2021). Marine Corrosion of Stainless Steels: Testing, Selection, Experience, Protection and Monitoring. United States: C.R.C. Press. **Galanakis C.M.** (2020). Microalgae: Cultivation, Recovery of Compounds and applications. Academic Press U.K. **Gerba C.P., Pepper I.L. and Maier R.M.** (2009). Environmental microbiology (*Spirulina*). Elsevier. **Graham, L.E., Graham, J. M. and Wilcox, L.W.** (2009). Algae. Spain: Benjamin Cummings. **Hallmann, A.** (2007). Algal transgenics and biotechnology. Transgenic Plant J, 1(1), 81-98. **Hans-Curt Flemming, P., Sriyutha Murthy. And R. Venkatesan** (2009). Marine and Industrial Biofouling. Springer Verlag Berlin Heidelberg Press. **Harald W. and Tietze.** (1999). Spirulina Micro Food Macro	

	Blessings, Harald W. Tietze Publisher. **Hasanuzzaman, M. and Vara Prasad M.N.** (2020). Handbook of Bioremediation. Physiological, Molecular and Biotechnological Interventions. Springer. **Kevin G. Sellner.** (2009). Physiology, Ecology, and Toxic Properties of Marine Cyanobacteria Blooms. American Society of Limnology and Oceanography Press. **León, R., Cejudo, A. G. and Fernández, E. (Eds.).** (2008). Transgenic microalgae as green cell factories (Vol. 616). Springer Science and Business Media. **Graham L.E., James, M., Graham. And Wilcox, L.W.** (2009). Algae. Benjamin Cummings. **Oskar R. Zaborsky.** (1998). Biohydrogen. Plenum Press, New York. **Robert Edward Lee.** (1999). Phycology (*Spirulina*). Cambridge University Press. **Singh, A. and Ward, O.P.** (2004). Applied Bioremediation and Phytoremediation. Springer. **Stengel, D.B., and Connan, S.** (2015). Marine algae: A source of biomass for biotechnological applications. In Natural products from marine algae (pp. 1-37). Humana Press, New York, NY. **Tiwari B. K., Declan J. Troy. (**2015). Seaweed Sustainability Food and Non-food products Ed, Academic Press Elsevier.	
Learning Outcomes:	Will enable to understand the role of algae in Biotechnology, and Environmental monitoring.	

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