Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

for 1 or 2 years M.Sc. Programme

as per guidelines of

NEP-2020

M.Sc. I - Botany

With effect from June 2023

	Program Outcomes (POs) for M. Sc. Programme
PO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the discipline that form a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	Critical Thinking and Problem solving: Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	Social competence: Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.
PO4	Research-related skills and Scientific temper: Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	Trans-disciplinary knowledge: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	Personal and professional competence: Performing independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic competence:** (i) Recall fundamental concepts, state principles and outline processes underlying in the field of Botany, its different subfields and its linkage with related disciplinary areas/subjects. (ii) Demonstrate an understanding of a wide range of physiological, biochemical, cellular, molecular, developmental processes in plant cell. (iii) Execute botanical excursion tour for correct taxonomic identification, collection, preservation of plant specimens.
PSO2	**Personal and Professional Competence:** (i) Carry out activities effectively as an individual or a member of a team or leader of a group to fulfil the responsibilities related to group activities. (ii) Analyse data and samples procured during experiments, projects, and field work. (iii) Formulate the ideas, draft scientific reports, authenticate conclusions, present effectively with effective communication skills. (iv) Implement self-learning, discipline, and take logical correct approach for solving problems.
PSO3	**Research Competence:** (i) Apply appropriate techniques to solve and analyse problems with specific reference to biological techniques and instrumentations. (ii) Integrate knowledge of fundamental aspects of Botany with applied aspects to design the experiment, interpret the data, and provide valid conclusions. (iii) Assess problems, identify, formulate research literature, and test probable solutions for challenges in various fields of Botany.
PSO4	**Entrepreneurial and Social competence:** (i) Employ the applied knowledge of Botany for self-employment with demonstration of true values of leadership, co-operation, and teamwork. (ii) Associate the impact of anthropogenic factors, importance of conservation, diversity, and our social role in sustainable development. (iii) Execute social competence including listening, speaking, observational, effective interactive skills and presenting skills to meet global competencies.

Fergusson College (Autonomous), Pune
Proposed First Year MSc Curriculum as per NEP 2020
Department of Botany
M. Sc. Botany Structure

I	**BOT-501**	**Systematics of Avascular Plants**	**4**
	BOT-502	**Metabolic processes in Plants**	**4**
	BOT-503 OR	**Industrial Techniques in Biology**	**4**
	BOT-504	**Biophysical Techniques**	
	BOT-510	**Research Methodology**	**4**
	BOT-520	**Practical - I**	**2**
	BOT-521	**Practical - II**	**2**
		Total Semester Credits	**20**
II	**BOT-551**	**Systematics of Vascular Plants**	**4**
	BOT-552	**Cellular Processes in Plants**	**4**
	BOT-553 OR	**Plant Pathology**	**4**
	BOT-554	**Plant Interactions**	
	BOT-560	**On Job Training / Field Project**	**4**
	BOT-570	**Practical - III**	**2**
	BOT-571	**Practical - IV**	**2**
		Total Semester Credits	**20**
		Total PG-I Credits	**40**

Semester	Paper Code	Paper Title	Credits
	BOT-601	**Inheritance Biology & Evolution**	**4**
	BOT-602	**Molecular Processes in Plants**	**4**
	BOT-603 OR	**Plant Ecology**	**4**
	BOT-604	**Environmental Botany**	
	BOT-610	**Research Project**	**4**
	BOT-620	**Practical - V**	**2**
	BOT-621	**Practical - VI**	**2**
		Total Semester Credits	**20**
IV	**BOT-651**	**Developmental Botany & Plant Tissue Culture**	**4**
	BOT-652	**Plant Biotechnology**	**4**
	BOT-653 OR	**Biostatistics & Bioinformatics**	**4**
	BOT-654	**Industrial Botany**	
	BOT-660	**Research Project**	**6**
	BOT-670	**Practical - VII**	**2**
		Total Semester Credits	**20**
		Total PG-II Credits	**40**

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	**15 / 30**	**1 / 2**	**25**	**10**	**15**
2	**30 / 60**	**2 / 4**	**50**	**20**	**30**
3	**45 / 90**	**3 / 6**	**75**	**30**	**45**
4	**60 / 120**	**4 / 8**	**100**	**40**	**60**

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

F.Y. M.Sc. Semester I	
Systematics of Avascular Plants (BOT501) **Credits:4**	
Course Outcome (CO) **On completion of the course, the students will be able to:**	
CO1	Outline the position of algae, fungi and bryophytes in latest classification system. List the morphological and anatomical characters of the group and give examples of each group.
CO2	Classify the groups and differentiate the taxonomic forms. Implement bioprospecting of fungi.
CO3	Interpret the life cycle strategies of various groups and illustrate them.
CO4	Categorize the lower plants and discriminate the groups from each other using salient features. Identify economic importance of the members of the lower groups.
CO5	Compare the orders with respect to range thallus organization, morphological and anatomical characters, pigmentation, reserved food, reproductive structures and life cycle patterns and interrelate them.
CO6	Arrange various taxonomic groups as per their evolutionary features.
Unit No.	**Title of Unit and Contents**
1	**Introduction to Algae (9L)** 2.1 An outline of general classification of algae by latest system 2.2 Cyanophyta: Ultrastructure; strategy of cell division; thallus organization 2.3 Brief introduction, structural and reproductive features of Chrysophyta, Xanthophyta, Bacillariophyta, Dinophyta
2	**Diversity of Algae I (6L)** 2.1 Chlorophyta: structure and evolution of thallus, life cycle patterns, reproduction 2.2 Charophyta and Euglenophyta: structure and reproduction
3	**Diversity of Algae II (7L)** 3.1 Phaeophyta: general account of external and internal morphology, reproduction and life cycle patterns 3.2 Rhodophyta: general account of external and internal morphology, reproduction and life cycle patterns
4	**Commercial products prepared from algae (1L)**
5	**Introduction to Fungi (3L)** 5.1 An outline of latest classification system (Spatafora *et al*., 2017) Overview of a higher-level phylogenetic classification of fungi (Kirk 2008 and Hibbett *et al.*, 2007) 5.2 Taxonomy of fungi: Characters of fungi used for classification

6	**Diversity of Fungi** 6.1 Structure, thallus organization, life cycle patterns, reproductive structures of the forms belonging to: Phyllum: Chytridiomycota, Neocallimastigomycota, Blastocladiomycota, Microsporidia, Mucoromycota (7L) 6.2 Ascomycota: thallus organization, centrum development, different types of ascocarps (6L) 6.3 Basidiomycota: tissue differentiation, development of basidia and basidiospore (4L)
7	**Bioprospecting of Fungi (2L)**
8	**Introduction to Bryophytes (2L)** 8.1 Morphological characters used for classification 8.2 Systems of classification of Bryophytes (Stotler & Stotler,2005) (Schimp)
9	**Diversity of Bryophytes (12L)** Distribution, morphological, anatomical, reproductive characters and comparative account of sporophytes and gametophytes and interrelationships along with their fossil relatives of the following orders: Calobryales, Sphaerocarpales, Marchantiales, Jungermanniales, Anthoceratales, Notothyladales, Takakiales, Sphagnales, Andraeales, Polytrichales, Buxbaumiales, Funariales.
10	**Economic Importance of Bryophytes (1L)**

Learning Resources

Algae:

1. Bellinger, E. G. and Sigee, D. C. (2010). Freshwater algae: Identification and use as bioindicators. Wiley-Blackwell, UK, pp. 271.
2. Brodie, J. and Lewis, J. (2007). (Ed.) Unravelling the algae: the past, present and future of algal systematics. CRC press, New York, pp. 335
3. Cole, K. M. and Sheath, R. G. (1990). Biology of the red algae. Cambridge University Press. USA, pp. 503.
4. Desikachary, T.V. (1959). Cyanophyta. ICAR, New Delhi.
5. Graham, L. E. and Wilcox, L. W. (2000). Algae. Prentice-Hall, Inc. pp. 640.
6. Krishnamurthy, V. (2000). Algae of India and neighbouring countries I. Chlorophycota, Oxford and IBH, New Delhi.
7. Lee, R. E. (2008). Phycology. Cambridge University Press, pp. 547.
8. Misra, J. N. (1966). Phaeophyceae in India. ICAR, New Delhi.
9. Prescott, G. W. (1969). The algae: A review. Nelson, London.
10. Smith, G. M. (1950). The fresh water Algae of the United States, Mc-graw Hill, Newyork.
11. Srinivasan, K. S. (1969) Phycologia India. Vol I and Vol II B.S.I. Calcutta.

Fungi:

1. Alexopolus, C. J., Minms, C. W. and Blackwell, M. (1999). (Fourth edition) Introductory Mycology, Wiley, New york. Alford, R. A. 1405130660.
2. Deacon, J. W. (2006). Fungal biology. (Fourth edition) Blackwell publishing, ISBN.
3. Kendrick, B. (1994). The fifth kingdom (paperback), North America, New York,
4. Kirk et al., (2001). (Ninth edition), Dictionary of the fungi, published Wallingford: CABI, ISBN: 085199377X.
5. Mehrotra, R. S. and Aneja, K.R. (1990). An introduction to mycology. New age publishers, ISBN 8122400892.

6. Miguel U., Richard, H. and Samuel, A. (2000). Illustrated dictionary of the Mycology, Elvira Aguirre Acosta, Publisher: St. Paul, Minn: APS press, ISBN 0890542570.

7. Webster, J. and Roland W. (2007) (Third Edition). Introduction to fungi, Cambridge Publisher: 3rd edition, ISBN- 10: 1585100226. University Press, 978-0-521-80739-5.

Bryophytes:

1. Cavers, F. (1976). The inter relationships of the bryophyte. S.R. Technic, Ashok

2. Chopra, R. N. and Kumar, P. K. (1988). Biology of bryophytes. John Wiley and Sons, New York, NY.

3. Kashyap, S. R. (1932). Liverworts of the Western Himalayas and the Panjab plain (illustrated): Part 2 The Chronica Boanica New Delhi.

4. Kashyap, S. R. (1929). Liverworts Of The Western Himalayas And The Panjab Plain Part 1 Chronica Botanica New Delhi.

5. Parihar, N. S. (1980). Bryophytes: An introduction to Embryophyta Vol I, Bryophya central Book Depot.

6. Prem puri (1981). Bryophytes: Morphology, Growth and Differentiation, Atma ram and Sons, New delhi.

7. Udar, R. (1975). Bryology in India: Chronica Botanica Co., [c], New Delhi.

8. Udar, R. (1970). Introduction to bryphyta, Shashidhar Malaviya Prakashan, Lucknow

9. Watson, E. V. (1971). Structure and life of bryophytes, Hutchinson University Library London.

Metabolic Processes in Plants (BOT502)
Credits:4

Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify the role of various enzymes and their importance in metabolic pathways.
CO2	Interpret the role of light in various developmental processes and the effect of stress on plants. Represent the mechanism of conduction and transport of water and minerals
CO3	Illustrate the roles of secondary metabolites in plant growth and defense.
CO4	Order the different steps in important metabolic pathways like mineral uptake and water transport.
CO5	Compare the structure, biosynthetic & metabolic pathways of primary metabolites and secondary metabolites.
CO6	Integrate the metabolic processes like photosynthesis and respiration and propose their dependence.
Unit No.	**Title of Unit and Contents**
1	**Photosynthesis (15L)** 1.1 Photosynthetic pigments, absorption and transformation of radiant energy, Light harvesting complexes, Chlorophyll fluorescence kinetics, determination of PSI & PSII efficiency 1.2 Kok curve, Kautsky curve, ETS, photo inhibition O2 and H2 evolution, photoprotection, regulation of Calvin cycle, RUBISCO activity, Photorespiration 1.3 CAM, C4 Pathway and its types 1.4 Reduction of carbon dioxide - RuBPcase and Calvin cycle, CO2 concentrating mechanisms in C4 and CAM plants. 1.5 Structure, biosynthesis and metabolism of carbohydrates.
2	**Respiration (10L)** 2.1 Glycolysis, Kreb's Cycle, pentose phosphate pathway 2.2 Organization of mitochondrial electron transport system, ATP synthesis, respiratory control, inhibitors and uncouplers of respiration, anaerobic respiration. 2.3 Alternative pathways in plants, alternate oxidase 2.4 Structure, biosynthesis and metabolism of fatty acid and lipids.
3	**Transport of water and minerals (8L)** 3.1 Properties of water and pH. 3.2 Mechanism of uptake and transport of water, SPAC, stomatal physiology 3.3 Mechanism of uptake and transport of macro elements & microelements 3.4 Structure, biosynthesis and metabolism of amino acids & proteins 3.5 Structure, biosynthesis and metabolism of nitrogen bases & nucleic acids
4	**Enzymology (5L)** 4.1 Classification and properties of enzymes 4.2 Enzyme coupled reactions, units of enzyme activity 4.3 Enzyme kinetics 4.4 Inhibitors, enzyme regulation.

5	**Photobiology (8L)** 5.1 Photoperiodism and vernalization. 5.2 Tropic and nastic movements in plants. 5.3 Structure, function and mechanisms of action of Phytochromes, Cryptochromes and Phototropins. 5.4 Stomatal movement and biological clocks.
6	**Secondary metabolites (7L)** 6.1 Major secondary metabolite synthesis pathways in plants (Alkaloids, Terpenoids and Phenolics). 6.2 Role of secondary metabolites with their applications
7	**Stress Physiology (7L)** 7.1 Physiological changes in various biotic (pathogenic) and abiotic (drought, salinity and temperature) stress conditions 7.2 Plant adaptive responses to stress conditions 7.3 Physiological role of regulators like salicylate, jasmonate, brassinosteroids and polyamines during stress

Learning Resources

1. Berg J.M., Tymoczko J.L., Stryrer L. (2002) (Fifth Edition) Biochemistry. Wlt. Freeman and Company, New York.
2. Buchanan B.B., Gruissem W., Jones R.L. (2000) Biochemistry and Molecular Biology of Plants. IK International, Mumbai.
3. Davis P. J. (Eds.) (2004) Plant Hormones. Kluwer Academic Publishers, Dordrecht, Netherlands.
4. Goodwin T.W., Mercer E.I. (1998) (Third Edition) Introduction to Biochemistry. CBS Publishers, New Delhi.
5. Heldt H. W. (2004) Plant Biochemistry. Academic Press, California.
6. Lawlor D.W. (2001) Photosynthesis in C3 and C4 Pathway. Viva, New Delhi.
7. Lincolin Taiz and Eduardo Zeiger (2010) (Fifth Edition) Plant Physiology. Sinauer Associates Inc. Publishers. Sunder land, USA.
8. Nelson David and Cox Michael. (2007) Lehninger Principles of Biochemistry. W. H. Freeman and Company. New York.

Industrial Techniques in Biology (BOT503) Credits:4	
Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify the uses of plants as per Ayurveda with respect to various commercial fields. Outlines use of plants in dyes and essence
CO2	Summarizes the evaluation of crude drug and its uses.
CO3	Outlines micropropagation methods of medicinal plants of immense importance
CO4	Analyze conventional methods of cultivation of medicinal plants and their impacts
CO5	Evaluate the plants from pharmacology point of view to learn their characters, chemical properties and uses.
CO6	Integrate the traditional knowledge with the concepts of Entrepreneurship and management.
Unit No.	**Title of Unit and Contents**
1	**Phytotechnology (7L)** 1.1 Introduction, concepts and prospects 1.2 Phyto-technology-value addition to biodiversity through chemo prospection 1.3 Traditional Medicinal plants mentioned in Ayurveda with their application
2	**Dyes (6L)** 2.1 Natural dyes for cotton and silk industry *Tecomella* leaves, Katha and *Ravenchi* wood, Seeds of *Bixa*, Babul flowers 2.2 Medicinal herbs for dying hair and in cosmetics
3	**Essence (2L)** Aromatic plants as important sources of essence
4	**Conventional Propagation Methods for Cultivation of Medicinal Plants (10L)** 4.1 Factors affecting Cultivation of Medicinal Plants 4.2 Diseases management of medicinal and aromatic plants 4.3 Method of cultivation and post harvest technology of medicinal plants cultivated in India: Senna, Opium, Ashwagandha, Lemongrass, Turmeric
7	**Micropropagation of Medicinal Plants (5L)** Culture media, explants, incubation conditions, stages of micropropagation, acclimatization and field trials (Case study-*Vinca rosea*, *Adhathoda vasica* and *Withania somnifera*)
8	**Evaluation of crude drugs (5L)** Evaluation of crude Drugs with respect to authenticity of raw material: Concept, considerations, parameters. Pharmacopoeia and other guidelines (FDA).
9	**Pharmacognostic Evaluation of Medicinal Plants (10L)** Geographical distribution, commercial varieties, adulterants and substitutes, cultivation, collection, macroscopic and microscopic characters, chemical constituents, chemical tests, therapeutic uses, commercial products if any. Root Drugs, Rhizome Drugs, Stem Drugs, Bark Drugs, Leaf Drugs, Flower Drugs, Fruit Drugs, Seed Drugs.

10	**Entrepreneurship (8L)** 10.1 **Entrepreneur**: Concept, characteristics of entrepreneur, types and functions of entrepreneur. 10.2 **Entrepreneurship Development Programmes** (EDPs) 10.3 **Project Identification and Selection** (PIS) -Meaning of project and report, project identification & selection, contents of project reports, preparation of project report. 10.4 **Institutional Finance to Entrepreneurs**-Commercial banks, other financial institutions 10.5 **Bank Institutional Support to Entrepreneurs** NSIC, SIDCO, SSIB, SSIDC, SISI's, DICS, Industrial Estates, NABARD
11	**Management (7L)** 11.1 **The Business** –Its Nature and Scope Meaning, characteristics, objectives and scope of business, interrelationship between industry, commerce and trade 11.2 **Fundamentals of Management**: Meaning, characteristics, difference between management and administration, management process, working capital management, inventory management, human resource management, production and operation management, marketing management 11.3 **Accounting**-need, meaning, objectives, journal, ledger, trial balance, final accounts-profits and loss accounts, balance sheet

References:

1. Pharmacognosy, Willium C. Evans, Saunders publications.
2. Textbook of Pharmacognosy, P. E. Wallis, CBS publishers and distributers.
3. Text book of Pharmacognosy, S. B. Gokhale, C. A. Kokate, A. P. Purohit, Nirali Publications
4. Entrepreneur Developments, S. S. Khanka, S. Chand., 2005
5. A Text Book of Microbiology, Dube and Maheshwari
6. A Text Book of Biotechnology. R C Dube

Biophysical Techniques (BOT504) Credits:4	
Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Name the chemicals used in a particular technique and their role
CO2	Discuss the principles of different techniques.
CO3	Generalize applications of different techniques.
CO4	analyze different preparatory, separation and analytical techniques with the help of diagrams, construction and use of the parts.
CO5	Explain the role of various techniques.
CO6	Specify the proper technique for preparation and analysis of given sample.
Unit No.	**Title of Unit and Contents**
1	**Making solutions (5L)** 1.1 SI System of measurement: Fundamental and derived units. 1.2 Moles and molarity, stock solutions and dilutions, making media and reaction mixtures 1.3 pH measurements and preparation of buffers
2	**Microscopy and microscopic techniques (10L)** 2.1 Sample preparation for different microscopy techniques. 2.2 Light, phase contrast, fluorescence, electron, confocal microscopy. 2.3 Micrometry. 2.4 Flow cytometry.
3	**Chromatographic techniques (8L)** Paper, thin layer and column chromatography, gel filtration, ion exchange and affinity chromatography, HPLC, GC
4	**Electrophoretic techniques (7L)** electrophoresis under native, dissociating and denaturing conditions, isoelectric focusing, staining, 2-D electrophoresis
5	**Radioactive techniques (7L)** 5.1 Isotopes and their half-life, Specific activity of radioisotopes, making radioisotope solutions 5.2 Detection and measurement of radioactivity - counters 5.3 Autoradiography
6	**Spectroscopic techniques (8L)** 6.1 UV -Visible, IR spectroscopy, spectrofluorimetry, NMR and ESR spectroscopy, circular dichroism spectroscopy, AAS. 6.2 Spectrometric techniques: mass spectrometry, MALDI-TOF
7	**Electrochemical techniques (3L)** 7.1 Construction and working of equipment for measurement of electrical conductivity 7.2 Construction and working of equipment for measurement of pH meter.
8	**Centrifugation techniques (4L)** 8.1 High speed centrifuges, rotors, ultracentrifugation 8.2 Density gradient centrifugation.
9	**Gas exchange measurements (3L)** Infra-red gas analyzer, O2 electrode

10	**Immunological techniques (3L)** Antibodies and their specificity, antigen-antibody interactions, Immunodiffusion, Immunoprecipitation and Immunoelectrophoresis techniques, RIA, ELISA, Immunofluorescence.
11	**Methods in field biology (2L)** 11.1 Ground and remote sensing 11.2 Use of GIS, GPS, Satellite imaging

Learning Resources:

1. P. Gunadegaram (1995). Laboratory Manual in Microbiology. New Age International (P) Ltd.
2. Srivastava M.L. (2008). Bioanylatical Techniques. Narosa Publishing House (P) Ltd.
3. Gamborg O.L., Philips G.C. (Eds.) (1995). Plant Cell, Tissue and Organ Culture Fundamental Methods. Narosa Publishing House (P) Ltd.
4. Krishnamurthy K.V. (1999). Methods in Cell Wall Cytochemistry. CRC Press. LLC.
5. Plummer David (1987). An Introduction to Practical Biochemistry. 3rd Eds. Tata McGraw-Hill Publishing Company Ltd.
6. Sadasivam S.,Manickam A. (1996). Biochemical Methods. 2nd Edn. New Age International (P) Ltd.
7. Khasim S.M. (2002). Botanical Microtechniques: Principles and Practice. Capital Publishing Company.
8. Harborne J.B. (1998). Phytochemical Methods. Springer (I) Pvt. Ltd.
9. Wilson K., Walker J. (2005). Principles and Techniques in Biochemistry and Molecular Biology. Cambridge University Press.
10. Wilson K., Walker J. (2000). Practical Biochemistry Principles and Techniques. Cambridge University Press.
11. Egerton R.F. Physical Principle of Electron Microscopy: an Introduction to TEM, SEM and AEM.
12. Bisen P.S. Mathur S. (2006). Life Science in Tools and Techniques. CBS Publishers, Delhi.
13. Marimuthu R. (2008). Microscopy and Microtechnique. MJP Publishers,Chennai.
14. Sharma V.K. (1991). Techniques in Microscopy and Cell Biology. Tata McGraw-Hill Publishing Company Ltd.
15. Prasad and Prasad (1984). Outline of Microtechnique. Emkay Publications, Delhi.
16. Srivastava S. and Singhal V. (1995). Laboratory Methods in Microbiology. Anmol Publication Pvt. Ltd. Delhi.
17. Annie and Arumugam (2000). Biochemistry and Biophysics, Saras Publishing, Tamilnadu.
18. Sass John E. (1984). Botanical Microtechniques. Tata McGraw-Hill Publishing Company Ltd
19. Pal and Ghaskadabi (2009). Fundamentals of Molecular Biology. Oxford Publishing

Research methodology (BOT510) **Credits:4**	
Course Outcome (CO) **On completion of the course, the students will be able to:**	
CO1	Learn the various aspects of the research process, framing useful research questions, research design, data collection, analysis, writing and presentation
CO2	Understand the research problem, methods/techniques to be adopted
CO3	Apply statistical tools for analysing the data while performing their research
CO4	Develop skills in qualitative and quantitative data analysis and presentation
CO5	Analyse for fitting, errors in the measurements and able to withdraw conclusions from the analysed data
CO6	Execute a quality research paper and patents in science and technology
Unit No.	**Title of Unit and Contents**
1	History of research, Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications. (12L)
2	Statistical analyses and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, Non-response and methods of recovering the missing response, Various software for statistical analysis. (12L) The module will consist of case studies of the research performed in various subjects using statistical methods, Error and noise analysis, curve fitting.
3	Literature search, selection of research topic (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, effective verbal and non-verbal communication, field data collection, safety in field. (12L)
4	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology. (12L)
5	Research Methodology for botanical work (12L) Methods of field studies: Collection of field data, samples, treatments, preservations, recording observations and documentation Methods of laboratory studies: Setting an experiment, deciding sample size, techniques to be used for analysis, recording observations and documentation 4.3 Methods of in-silico studies: Data acquisition, analysis, interpretation with appropriate software tools
	References: 1. 'History of the Scientific Methods' by Martin Shuttleworth, https://explorable.com/history-of-thescientific-method. 2 'The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664

Botany Practical - I (BOT520)
Credits: 4

Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify and name the specimens with vegetative and reproductive parts.
CO2	Explain thallus range using fresh and preserved plant materials. Estimate citric acid by titration and interpolate the result
CO3	Examine the vegetative and reproductive structures and predict the position of specimens in classification.
CO4	Compare the groups to find the interrelations and discriminate them from each other. Learn to study SEM/TEM drawings.
CO5	Justify the position of specific specimens in particular divisions and support the explanation. Perform application-based experiments.
CO6	Generate inventory of the specimens by exploring a given area, write a report, collect the representative specimens of the key groups and make herbarium.

Practicals based on Algae (Any 6P) -

Practical No.	Title
	Morphological observations, documentation (description and illustrations) and classification according to Fritsch with reasons of taxa belonging to-
1	Chlorophyta-Unicellular to colonial forms
2	Chlorophyta- Filamentous forms
3	Chlorophyta- Parenchymatous forms
4	Charophyta,
5	Phaeophyta,
6	Rhodophyta,
7	Cyanophyta,
8	Minor Groups
9	To study different stages of *Spirulina* culture
10	Collection, characterization and identification of algae from diverse habitats
11	Algal herbarium Preparation
12	Study of SEM/TEM photographs of algae published in standard publications.

Practicals based on Fungi (Any 6P)-

1	Study of Lichens
	Study of representative genera belonging to following subdivisions of fungi with respect to vegetative, reproductive structures and classification with reasons according to Ainsworth et al. (1973) (At least two examples from each class):
2	Myxomycotina,
3	Mastigomycotina,
4	Zygomycotina,
5	Deuteromycotina,
6	Ascomycotina,
7	Basidiomycotina
8	Isolation and culture of soil fungi/ water fungi
9 and 10	Preparation of PDA for fungal growth using soil dilution method, identification of fungi and slide preparation

11 and 12	Citric acid production and estimation by titration method

Practicals based on Bryophytes (Any 3P)-

	Study of representative genera belonging to:
1	Marchantiales- *Riccia*, *Cyathodium*, *Marchantia*,
2	Marchantiales- *Plagiochasma*, *Targionia, Astrella.*
3	Anthocerotales
4	Funeriales
2	Study of antibacterial activity of bryophytes

Botany Practical - II (BOT521)
Credits:4

Course Outcome (CO)
On completion of the course, the students will be able to:

CO1	Prepare solutions with appropriate concentrations. Identify different stages of mitosis and meiosis.
CO2	Estimate the enzyme activities and compare the effect of different factors on enzyme activities. Categorize different fossil types by studying the characters.
CO3	Use proper method for analysis of biochemical contents of different plant parts. Execute the method to carry out steps to demonstrate mitosis, meiosis and polyploidy.
CO4	Deconstruct the different concepts of genetics and solve problems based on them.
CO5	Assess the results of experiments, calculate the results of experiments and interpret it with the help of graphs. Discriminate the organisms on the basis of sexual dimorphism.
CO6	Plan and perform the experiments, compile the observations, draw conclusions and propose the result.

Practicals based on metabolic processes in plants (Any 10P)

Practical No.	Title
1	Preparation of solution of different concentrations, buffers, conductivity and pH measurements
2	Enzyme assays – extraction and estimation of enzyme activity- Catalase/ peroxidase/ invertase (Any one)
3	Effect of pH and enzyme concentrations on enzyme activity
4 & 5	Effect of substrate concentration on rate of enzyme action and calculation of Km by Michalie's Menten Curve
6 & 7	Estimation of soluble proteins in germinating and non-germinating seed by Lowry and Bradford's method
8	Estimation of ascorbic acid in ripe and unripe fruits
9	Studies on induction of amylase activity by GA_3 in germinating cereal grains
10	Estimation of reducing sugars
11	Effect of salt stress on proline accumulation and its estimation
12	Study of stomatal physiology
13	Study of effect of salt stress on overall plant physiology

Practicals based on Industrial Techniques in Biology (Any 5P)

1	Essence or aromatic oil extraction using soxhlet apparatus
2	Anatomical study of medicinal plant parts
3	Evaluation of crude drug raw material
4	Qualitative tests for detection of secondary metabolites
5	Propagation of medicinally important plants
6	Writing of project proposal and presentation for start up
7	Visit to Management Institute and writing of report

OR

Practicals based on Biophysical Techniques (Any 5P)

1	Handling of compound microscopes
2	Micrometry
3	Maceration technique
4	Electrical conductivity & pH measurement
5	Absorption spectra of BSA/DNA, determination of absorption maxima
6	Gel filtration
7	Ouchterlony double diffusion technique for testing antigen & antibody
8	Separation of leaf pigments by paper chromatography & TLC
9	Microtomy- Processing, sectioning, staining.
10	Use of QGIS

F.Y. M.Sc. Semester II	
Systematics of Vascular Plants (BOT551) Credits:4	
Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Outline the position of Pteridophytes, Gymnosperms and Angiosperms in latest classification.
CO2	Classify the specimens and associate them with salient features, distribution, morphology, anatomy and reproductive structures of their respective orders.
CO3	Examine the taxonomic characters, systematic position, illustrate the life cycle strategies.
CO4	Discriminate primary and evolved characters of various orders and relate the orders with each other.
CO5	Identify economic importance, draw floral diagrams and formulae and determine interrelationships between families
CO6	Integrate the data of characters of different groups to design evolutionary development amongst the groups.
Unit No.	**Title of Unit and Contents**
1	**Introduction to Pteridophytes** 1.1Characteristic features and diversity of Pteridophytes, affinities with Bryophytes and Algae 1.2 Recent systems of classification- PPG I, (2016)
2	**Diversity of Pteridophytes** Comparative account of distribution, morphology, anatomy, gametophyte, sporophyte and interrelationships of following orders– Lycopodiales, Isoetales, Selaginallales, Equisetales, Psilotales, Ophioglossales, Marattiales, Osmundales, Salviniales, Pteridinae
3	**Evolution in Pteridophytes** 3.1 Apogamy, apospory 3.2 Telome theory, stelar and soral evolution, gametophyte evolution, 3.3 Heterospory and seed habit.
4	**Introduction to Gymnosperms** 4.1Classification system of Gymnosperms (Christenhusz,2011) 4.2 Geographical distribution, characteristic features 4.3 Affinities with pteridophytes and angiosperms.
5	**Diversity of Gymnosperms** Comparative account of morphology, anatomy, sporogenesis, gametogenesis, embryology, and interrelationships of - Cycadales**,** Ginkgoales, Welwitschiales, Ephedrales, Gnetales, Pinales, Aurocariales, Cupressales
6	**Economic importance of pteridophytes & gymnosperms**

7	**Introduction to Systematics of Angiosperms** 7.1 Principles and methods in taxonomic research 7.2 Botanical survey of India 7.3 Conventional Tools 7.4 Modern Tools 7.5Morphological features used in classification, identification. Taxonomic Keys and types
8	**International Code of Botanical Nomenclature**: 8.1 Salient Features-Principles 8.2 Important Rules and Recommendations 8.3 Provisions for the governance of the Code 8.4 Appendices.
9	**Classification systems** 9.1 Artificial - Linnaeus 9.2 Natural – Bentham and Hooker, Bessey 9.3 APG systems of classification 9.4 Robert Thorne's classification system
10	**Morphological variations, systematic position, interrelationship, phylogeny** and **economic importance of following families:** 10.1 Polypetalae- Nympheaceae, Papavaraceae, Ranunculaceae, Tiliaceae, Rosaceae, Sapindaceae, Rutaceae(Any 4) 10.2 Gamopetalae- Malphigiaceae, Sapotaceae, Oliaceae, Boraginaceae, Convolvulaceae, Scrophulariaceae, Bignoniaceae (Any 4) 10.3 Apetalae-Polygonaceae, Phyllanthaceae, Euphorbiaceae, Loranthaceae, Urticaceae, Moraceae, Casurinaceae (Any 4) 10.4 Monocotyledonae- Musaceae, Commelinaceae, Liliaceae, Cyperaceae, Poaceae, Orchidaceae (Any 4)

Learning Resources:

1. Agashe SN (1995) Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd., New Delhi.
2. Anold AC (2005 Repr.) An Introduction to Paleobotany, Agrobios (India), Jodhpur.
3. Bhatnagar S and Motia A (1996) Gymnosperms. New Age International, New Delhi.
4. Biswas C and Johri BM (1997) Gymnosperms. Narso. Pub., New delhi.
5. Chamberlain CJ (1986) Structure and Evolution. CBS Publishers, New Delhi
6. Eames EJ (1983) Morphology of Vascular Plants. Standard University Press.
7. Johari M, Sneh Lata and Kavita Tyagi (2012) A textbook Gymnosperm, Dominant Publishers and Distributors, New Delhi.
8. Rashid A (1999) An introduction to Pteridophyta. Vikas Publishing house Pvt. Ltd., New Delhi.
9. Sharma O P (1990) Textbook of Pteridophyta, Mac Millan India Ltd., Delhi.
10. Singh V P (2006) Gymnosperms (Naked seed plants): Structure and development, Sarup and sons, New Delhi.
11. Smith GM (1955) Cryptogamic Botany Vol. II Mc Grew Hill.
12. Sporne KR (1986) The morphology of Pteridophytes, Hutchinson University Press, London.
13. Stewart WN and Rothwell GW (2005) (Second Edition), Paleobotany and the Evolution of plants, Cambridge University Press.
14. Sundara Rajan S. (1999) Introduction to Pteridophyta, New Age International Publishers, New Delhi.
15. Surange KR (1966) Indian fossil Pteridophytes, Council of Scientific and Industrial research.
16. Parihar NS (1976) Biology and morphology of the Pteridophytes. Central Book Depot.

17. Cook T (1903). The Flora of Presidency of Bombay, Vol. I (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.
18. Cronquist A J (1988). Evolution and Classification of Flowering Plants, 2nd edn, N Y Botanical Garden.
19. Davis P H and Heywood V H (1963). Principles of Angiosperm Taxonomy, Oliver and Boyd.
20. Eames A J (1961). Morphology of Angiosperms, McGraw Hill Book Co.
21. Erdtman G (1966). Pollen Morphology and Plant Taxonomy of Angiosperms (An introduction to Palynology I), Hafner Pub. Co. London.
22. Hickey M and King C (2000). The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press, UK.
23. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.
24. Jones S B and LuchingerA E (1986). Plant Systematics 2nd edn, McGraw Hill BookJudd et al. (2007) 10. Plant Systematics – A phylogenetic approach. Sinauer Pub. 3rd edition
25. Kubitzki K (1977). Flowering Plants Evolution and Classification of Higher Categories. Plant Systematics – Evolution Supplement I.
26. Lawrence G H M (1951). Taxonomy of Vascular Plants, Macmillan.
27. Mabberly T J (1997). The Plant Book 2nd edn Cambridge University Press, Cambridge.
28. Naik V N (1984). Taxonomy of Angiosperms, TMH, New Delhi.
29. Radford A E (1986). Fundamentals of Plant Systematics, Harper and Row N
30. Simpson M. Plant Systematics Academic Press, 2nd edition.
31. Singh G (2004). Plant Systematics, 2nd edn, Oxford and IBH, New Delhi.
32. Sivrajan V V (1984). Introduction to Principles of Plant Taxonomy, Oxford and IBH, New Delhi.
33. Smith P M (1976). The Chemotaxonomy of Plants, Edward Arnold Pub. Ltd.
34. Sporne K R (1974). Morphology of Angiosperms, Hutchinson University Library, London.
35. Stace C A (1989). Plant Taxonomy and Biosystematics. Bhojwani S. S. and Bhatnagar S. P. (1999). The embryology of angiosperms. Vikas Pub. House.

Cellular Processes in Plants (BOT552)
Credits:4

Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Outline the different cellular processes.
CO2	Compare different cell signaling pathways.
CO3	Execute the importance of different components of the secretory pathway in correct order.
CO4	Explain molecular and functional aspects of various processes in cell life cycle, apoptosis, cell senescence.
CO5	Support the crucial roles of plant specific cell organelles using ultrastructure and biogenetic pathway.
CO6	Specify the molecular functional aspects of cell organelles.
Unit No.	**Title of Unit and Contents**
1	**Introduction** Cell theory and cell structure, Biogenesis of cell organelles
2	**Cell wall** 2.1 Biogenesis, ultra structure and function. 2.2 Growth - primary and secondary wall 2.3 Plasmodesmata – Structure and role in movement of molecules.
3	**Cell membranes** 3.1 Molecular organization, transport of ions and solutes across membranes 3.2 Chloroplast and mitochondrial membranes.
4	**Functional aspects of cell organelles** 4.1 Vacuoles - Tonoplast, biogenesis, transport across vacuolar membrane 4.2 Nucleus- Structure, organization and regulation of nuclear pore complex. Transport across nuclear membrane. 4.3 Ribosomes – Structure, assembly and dissociation of subunits, function.
5	**Secretory Pathway** 5.1 Endoplasmic reticulum- Role in synthesis and transport of Secretory proteins 5.2 Golgi complex – role in sorting, storage and secretion 5.3 Lysosomes, Glyoxysomes and Peroxisomes- structure and functions
6	**Cytoskeleton** 6.1 Composition, organization and role of microtubules, microfilaments, intermediate filaments. 6.2 Flagella- Structure and organization.
7	**Signal transduction I** 7.1 Types and functions of receptors, second messengers 7.2 Regulation of signaling pathways, cell-cell interactions 7.3 Signaling pathways- Phospholipid signaling, Ca++-calmodulin cascade 7.4 Diversity in protein kinases and phosphatases, Receptor Serine / Threonine kinase
8	**Signal transduction II** 8.1 Specific signaling mechanisms with suitable examples – biotic and abiotic stress, ABA induced stomatal closure 8.2 Nuclear-organelle signaling during plastid development, Ethylene mediated two component system

	8.3 Bacterial chemotaxis and quorum sensing
9	**Cell Cycle** 9.1 Phases of cell cycle, functional importance of each phase, molecular events during cell cycle, check points, cyclins and protein kinases, MPF (maturation promoting factor), 9.2 Regulation of cell cycle 9.3 Applications of cell cycle studies.
10	**Cell senescence, PCD and apoptosis** 10.1 Cell aging and cell senescence 10.2 Programmed cell death- molecular aspects, regulation of cell death, PCD in response to stress 10.3 Role of different genes, cell organelles during apoptosis, genetic control of apoptosis

Learning Resources

1. Alberts B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1989. Molecular biology of the Cell (2nd edition). Garland Pub. Inc., New York.
2. Karp, G. 1999. Cells and Molecular Biology: Concepts and Experiments. John Wiley and Sons, Inc., USA.
3. Lodish S, Baltimore B, Berk, C and Lawrence K, 1995, Molecular Cell Biology, 3rd edn, Scientific American Books, N.Y
4. De Robertis and De Robertis, 1988, Cell and Molecular Biology, 8th edn, Info-Med, Hongkong.
5. Buchanan, Grissem and Jones, 2000, Biochemistry and Molecular Biology of Plants, American Soc. Plant Biologists, Waldorf.
6. Lewin, B. 2000. GENE VII. Oxford University Press, New York, USA
7. Cooper G M and Hausman R E, 2007, The Cell: Molecular Approach 4th Edn, Sinauer Associates, USA.

Plant Pathology (BOT553)
Credits:4

Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify various types of diseases with examples, causes and symptoms.
CO2	Understands the methods of pathogenesis and its effect on plant physiology.
CO3	Predicts the role of environmental factors on the plant pathogen association
CO4	Specifies Plant defense mechanism and its importance.
CO5	Integrates genetic and molecular basis of plant pathogen interaction.
CO6	Explains role of disease management and need of improving resistance of the plants.

Unit No.	Title of Unit and Contents
1	**Introduction to Plant Pathology** 1.1 Milestones in plant pathology, Plant pathology and its objectives 1.2 Nature and concept of plant disease, classification of plant diseases, causes of plant diseases, symptoms of plant diseases, disease cycle
2	**Types of Diseases** 2.1 Bacterial and fungal diseases of plants. 2.2 Viral diseases of plants 2.3 Nematodal diseases of plants 2.4 Post Harvest Diseases of plants
3	**Plant Disease Epidemics** 3.1 Plant disease epidemiology and forecasting of plant disease epidemics. 3.2 Effect of plant diseases on human affairs
4	**Pathogenesis** Penetration, infection and spread of diseases
5	**Effect of pathogen on Plant Physiological functions** 5.1 Enzymes and toxins in Plant Diseases 5.2 Pathogenecity of Biotrophic and Necrotrophic Pathogens
6	**Environmental Factors and Disease Development** Effect of temperature, humidity, soil pH, soil texture, light, CO_2 and O_2 levels, nutrients on disease development
7	**Plant Defense Mechanisms** 7.1 Pre-existing defense 7.2 Defense through lack of essential factors 7.3 Induced structural and biochemical defense
8	**Genetics and Molecular Biology of Pathogen Interactions** 8.1 Genetics of host parasitic interactions 8.2 Vertical and horizontal resistance 8.3 Pathogenesity genes, avirulance genes, host-R genes.
9	**Disease Management** 9.1 Diagnostic methods for detecting pathogens 9.2 Control of disease using fungicides and other chemicals Bio-control agents for controlling disease 9.3 Disease control using biological and chemical activators of resistance 9.4 Plant Disease Assessment

10	**Improving Resistance in Plants** Breeding methods for improving resistance in plants Biotechnology and its role in plant pathology

Learning Resources:

1. Plant Pathology by R. S. Mehrotra, first edition, McGraw-Hill Education publication, 1982.
2. Plant Pathology by George N Agrios, fifth edition, Academic Press, London, 2005.
3. Plant Nematode: Morphology, Systematics, Biology and Ecology by M. R. Khan, first edition, Science Publishers, 2008.
4. Plant Pathogenesis and Resistance by Jeng-Sheng Huang, first edition, Springer, Netherlands, 2001.
5. Plant Pathology by R. S. Mehrotra and Ashok Agarwal, second edition, Tata McGraw Hill Education, 2003.
6. Biocontrol of Plant Diseases by P. C. Trivedi, first edition, Aavishkar Publishers and Distributors, 2007.
7. Concise Encyclopedia of Plant pathology by P. Vidhyasekaran, first edition, CRC Press, 2004.
8. Topics in Mycology and Pathology by L. N. Nair, first edition, New Central BookAgency Kolkata, 2007.
9. Fundamentals of plant pathology by A.K. Sinha, Kalyani Publishers
10. Disease of crops plants of India by Rangswami and Mahadevan, Prentice Hall Publication

Plant Interactions (BOT552) Credits:4	
Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify type of interaction with suitable examples.
CO2	Understand the mechanism involved behind avoiding herbivory and developing carnivorous, epiphytic and parasitic association.
CO3	Examine the relationship between pollinators- flowers and coevolution.
CO4	Discuss plant microbe interactions and its importance
CO5	Compare positive and negative interactions and mechanisms involved.
CO6	Integrate the knowledge of associations to understand complex behavior of plants.
Unit No.	**Title of Unit and Contents**
1	**Plant- Plant Interactions (10L)** 1.1 Allelopathy in plants 1.2 Competitive interactions in plants 1.3 Parasitic association in plants 1.4 Epiphytic plants
2	**Plant- Animal Interactions (8L)** 2.1 Herbivores–insect-plant interactions, grazing animals–physical and biochemical interactions, Plant signaling and chemical defense against herbivores. 2.2Carnivorous plants – morphological features, specialized biochemical mechanisms for nutrient processing
3	**Plant- Microbe Interactions (15L)** 3.1 Endosymbiotic theory 3.2 Lichens, Mycorrhizae and plant roots 3.3 Endophytes: Algae, Fungi, bacteria 3.4 Nodulating bacteria and Legume, Algae & corals, Fungi & insect relationship
4	**Pollination Biology (11L)** 4.1 Pollination types & mechanisms Flower structure with reference to pollination mechanisms, mimicry, thermogenesis. 4.2 Plant- Pollinator association Bees, beetles, butterflies, birds, mammals 4.3 Co-evolution Pollinators and plants, Fig-fig wasp' interaction, Hummingbird-plant interactions
5	**Seed Dispersal Mechanisms (4L)** Fruit and seed morphology relevant to seed dispersal
6	**Fungi-animal association (4L)** Fungi causing nuisance-Deuteromycosis (Ringworm), Mycetoma, Aspergillosis, Mucoromycosis, Candidiasis
7	**Nuisance causing Algae (4L)** Algal blooms Dinoflagellates

Learning Resources:

1. Walter Larcher 1995 “Physiological Plant Ecology”. 3rdEds. Springer – Verlag, New York Berlin Heidelberg
2. Zdenek, Lastuvka, Barbara Politycka, S. S. Narwal, Jana Kalinova 2007, “Coactions and Competition in Higher Plants”, Scientific Publisher (India).
3. Malcolm C. Press, Jonathan D. Graves 1995, “Parasitic Plants”, Chapman & Hall, 2-6 Boundary Row, London.
4. Peter Scott 2008, “Physiology and Behaviour of Plants”. John Wiley & Sons Ltd.
5. R.S. Mehrotra. Introduction to Mycology. Wiley Eastern.
6. Hans Lamberts and Thijs L. Pons Plant Physiological Ecology, Springer Publication.
7. Kuby, Immunology.

On Job training / Field Project (BOT560) Credits:4	
Course Outcome (CO) **On completion of the course, the students will be able to:**	
CO1	Outlines the project and carries out the steps in sequence
CO2	Discusses the problem statement and comes up with procedures
CO3	Examines neighboring area and carries out survey.
CO4	Integrates the theory knowledge and field experience to draw the conclusions
CO5	Evaluates the results and writes a project report.
CO6	Visits techno commercial processes and analyses the processing of the units
Unit No.	**Title of Unit and Contents**
1	**Student has to undertake either On Job Training or Field Project** **The necessary details for on job Training course are as follows:** A student can complete Training in any Biotech industry / Agro based Industry/ Research institute/ Academic institute / with a research project of a teacher / an expert funded by any funding agency for a minimum period of 4 weeks. **On Job Project** Student has to submit a training report at the end of the second semester. The student must include the project completion certificate issued by the respective industry/research institute/educational institute in the report. A student will submit three hard bound copies: Student Copy, Department copy, CoE copy of the work carried out during project work. The Project Report should include followings: ♣ Introduction ♣ Review of Literature ♣ Aims and Objectives ♣ Material and Methods ♣ Observations ♣ Result and Conclusion ♣ Bibliography
2	**The necessary details for field project are as follows:** A student has to visit at least four units of the followings and submit detailed report: 1. Biofertilizer Unit 2. Mushroom cultivation unit 3. Green house unit 4. Floriculture unit 5. Plant nursery unit 6. Garden designing and maintenance unit 7. Fruit processing unit 8. Bio-pesticide unit 9. Biomass briquette unit 10. Biofuel units 11. Plant tissue culture industries 12. Farmhouse management 13. Pomoculture units

	14. Organic farming 15. Fresh vegetables and flower supply unit 16. Herbal product industry 17. Forest department unit 18. Medicinal plant garden 19. Effluent treatment plant 20. Solid waste management unit
3	A student has to undertake survey of a given area with respect to plant diversity and submit a report Student has to identify an area of project (Plant pathology or plant interactions or any other) and perform field work to collect, identify, preserve and submit whole plant specimens, or plant parts. If required, has to study anatomy with preparation of permanent slides and document the results using photography
4	A student has to identify (Using Local Flora) and prepare herbarium of at least 25 specimens of grasses and weeds of the specified area. Students learn the use of google lens for identification in addition to traditional methods. Or student has to prepare digital herbarium of at least 25 plant specimens

Botany Practical - III (BOT570)
Credits:4

Course Outcome (CO) On completion of the course, the students will be able to:	
CO1	Identify and name the specimens of pteridophytes and gymnosperms with the help of vegetative and reproductive parts.
CO2	Explain the plant body with the help of anatomy and vegetative and reproductive structures.
CO3	Classify the preserved and live specimens and organize them in different orders.
CO4	Identify Inflorescence types, aestivation, adhesion and cohesion of whorls
CO5	Section the specimens and discriminate the wood anatomy characters of Gymnosperms. Assess morphological and reproductive characters of families
CO6	Write a tour report, collect the specimens and organize the herbarium sheets in the order of evolution.

Practicals based on Pteridophytes- (Any 5P)

Pract. No.	Title
1-9	Morphological and/or anatomical and/or reproductive studies of the following members with the help of live material/or herbarium specimens and/or museum specimens and/or permanent slides of the following orders: (any 8 orders) Psilotales, Lycopodiales, Selaginellales, Isoetales, Equisetales, Ophioglosales, Osmundales, Filicales, Salviniales
10	Excursion tour for collection of plants and preparation of report (At least 5 days)
11	Digital herbarium preparation
12	Study of antimicrobial activity of pteridophytes

Practicals based on Gymnosperms- (Any 5P)

1	Study of available fossils of gymnosperms
2-8	Morphological and / or anatomical and/or reproductive studies of the following members with the help of live material / or herbarium specimens and / or museum specimens and / or permanent slides of the following orders: Cycadales, Coniferales- *Pinus, Cupressus, Podocarpus, Juniper, Araucaria, Agathis* Gnetales Case study of specific genera of ginkgoales, coniferales and cycadales
9	Wood anatomy of conifers
10	Excursion tour for collection of plants and preparation of report (At least 5 days)
11	Digital herbarium preparation

Practicals based on Angiosperms- (Any 5P)

1-2	Study of Inflorescence, Aestivation, adhesion and cohesion of Floral whorls
3-8	Study of at least 12 locally available families of flowering plants
9	Identification of family of locally available plants.
10	Identification of genus and species of locally available wild plants using flora
11-12	Preparation of artificial keys based on vegetative and reproductive characters
13	Case study of plant species from a particular family and their comparative

	study
14	Excursion to study the local flora

Botany Practical - IV (BOT571)
Credits:4

Course Outcome (CO)
On completion of the course, the students will be able to:

CO1	Describe DNA and protein gel electrophoresis technique.
CO2	Interpret the structural properties of cell organelles with the help of electron micrographs.
CO3	Apply differential centrifugation technique to isolate various cell organelles and evaluate their properties with different methods.
CO4	Discriminate the cell types with the help of cytochemical techniques.
CO5	Assess the result of electrophoresis and genetic engineering techniques.
CO6	Plan and perform the experiments, compile the observations, draw conclusions and interpret the result.

Practicals based on Cellular Processes in Plants- (Any 10P)

Practical No.	Title
1	Differential centrifugation for isolation of cell fractions – Nuclear fraction
2 3	Isolation of chloroplasts to study: a. Hill reaction to measure intactness, b. Measurement of size of chloroplasts using micrometry and chlorophyll estimation
4	Isolation of mitochondria for estimation of succinic dehydrogenase activity
5	Isolation of lysosomal fraction and estimation of acid phosphatase activity
6	Study of electron micrographs of cell organelles
7	Study of metaphase nucleus: Localization of euchromatin and heterochromatin.
8	Cytochemical studies of special cell types- guard cells, senescent cells, bundle sheath cells.
9	Cytochemical studies of special cell types- meristematic cells, laticiferous cells, glandular cells, pollen grains.
10	Study of induced cell senescence in leaf discs
11	Micrometry to study different cell sizes: Plant cells, Fungal cells
12	Study of programmed cell death in plants

Practicals based on Plant Pathology- (Any 5P)

1	Study of any two bacterial, nematodal and viral diseases of plants
2	Study of six fungal diseases
3	Study of pure culture of fungi by streak plate and pour plate culture
4	Isolation of fungal pathogen from leaves, stem and roots
5	Study of enzyme activity in diseased plant material (Catalase/Peroxidase/Polyphenol Oxidase/Any Other)
6	Sectioning and observations of post harvest diseases of commercially important plants

OR

Practicals based on Plant Interactions- (Any 5P)

1	Study of nodulating bacteria
2	Study of allelopathic interactions in plants
3	Case study of epiphytic, parasitic, carnivorous plants
4	Collection and submission of at least five seed specimens with different

	dispersal mechanisms
5	Study of morphology and anatomy of lichens
6 and 7	Isolation, picking and identification of mycorrhizal spores from rhizosphere soil, Observation of AM and VAM using root maceration technique