



Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Botany

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Botany) Part-I

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: M.Sc. Botany

Preamble :

M Sc Botany program is designed with an objective to encourage and support the growing demands and challenging trends in the educational scenario. Our training focuses on the all-round development of the students to face the competitive World.

OBJECTIVES OF THE M SC BOTANY PROGRAMME:

1. Understand the scope and significance of the discipline.
2. Imbibe love and curiosity towards nature through the living plants.
3. In order to make students open-minded and curious, we try our best to enhance and develop a scientific attitude.
4. We make the students fit for the society by enabling them to work hard.
5. Make the students exposed to the diverse life forms.
6. Make them skilled in practical work, experiments, laboratory equipment and to interpret correctly on biological materials and data.
7. Develop interest in Biological research.
8. Encourage the students to do research in related disciplines.
9. Develop a thirst to preserve the natural resources and environment.
10. Develop the ability for the application of acquired knowledge in various fields of life so as to make our country self-sufficient
11. Appreciate and apply ethical principles to biological science research and studies

PROGRAM SPECIFIC OUTCOMES (PSO) OF MSc BOTANY:

Plant science is now an amalgamation of basic and applied science. Plants besides being the unique capability of plants to trap solar energy and provide food to all cannot be replicated by any system. Conventional studies like plant identification are now being supplemented with molecular techniques like DNA Barcoding. The courses have been designed to benefit all Botany students to study various aspects of plant science including its practical applications. Keeping in mind that these students can take up teaching at different levels, research work in research institutes and or industry, doctoral work,

environment impact assessment, biodiversity studies, entrepreneurship, scientific writing relevant topics have been included in the curriculum.

PSO 1: Understanding the classification of plants from cryptogams to Spermatophyte. Identification of the flora within field enhances basics of plants. Study of biodiversity in relation to habitat will correlates with climate change, land and forest degradation. Application of Botany in agriculture is through study of plant pathology.

PSO 2: Understand the ultra structure and function of cell membranes, cell communications, signaling, genetics, anatomy, taxonomy, ecology and plant Physiology and biochemistry. To understand the multi functionality of plant cells in production of fine chemicals and their wide spread industrial applications.

PSO 3: Molecular and Physiological adaptations in plants in response to biotic and abiotic stress. Genes responsible for stress tolerance genetic engineering of plants.

Structure for M. Sc. Botany First Year:

Year	Semester	Course Type	Course code	Course Name	Credits
1	1	Core Compulsory Theory paper	BOUT 111	Botany Theory Paper 1-Plant Systematics I	4
			BOUT 112	Botany Theory Paper 2- Cell Biology	4
			BOUT 113	Botany Theory Paper 3- Cytogenetics and Plant Breeding and Evolution	4
		Choice Based optional paper	BODT 114	Botany Theory Paper 4- a) Biofertilizer and Algal Technology OR b) Pomoculture and Fruit Processing Technology	2
			BODP 114	Botany Practical Paper 4-based on BO 114	2
		Core Compulsory practical paper	BOUP 115	Botany Practical Paper based on BOUT 111, BOUT 112 and BOUT 113	4
1	2	Core Compulsory Theory paper	BOUT 121	Botany Theory Paper 1-Plant Systematics II	4
			BOUT 122	Botany Theory Paper 2- Molecular Biology	4
			BOUT 123	Botany Theory Paper 3- Biochemistry	4
		Choice Based optional paper	BODT 124	Botany Theory Paper 4- a. Floriculture and Nursery Management OR b. Mushroom Cultivation and Biopesticide Technology	2
			BODP 124	Botany Practical paper 4- based on BODP 124	2
		Core Compulsory practical paper	BOUP 125	Botany Practical paper based on BOUT 121, BOUT 122 and BOUT 123	4

Structure for M. Sc. Botany Second Year:

Year	Semester	Course Type	Course code	Course Name	Credits
1	1	Core Compulsory Theory paper	BOUT 231	Botany Theory Paper 1	4
			BOUT 232	Botany Theory Paper 2	4
			BOUT 233	Botany Theory Paper 3	4
		Choice Based optional paper	BODT 234	Botany Theory Paper 4	2
			BODP 234	Botany Practical Paper 4	2
		Core Compulsory practical paper	BOUP 235	Botany Practical Paper	4
1	2	Core Compulsory Theory paper	BOUT 241	Botany Theory Paper 1	4
			BOUT 242	Botany Theory Paper 2	4
		Choice Based optional paper	BODT 243	Botany Theory Paper 3	4
			BODP 243	Botany Practical paper3	4
			BODT 244	Botany Theory Paper 4	2
			BODP 244	Botany Practical Paper 4	2
			Core Compulsory practical paper	BOUP 245	Botany Practical paper

Semester I

BOUT 111: Botany Theory Paper I-Plant Systematics I (4 Credit- 60 Lectures)

Credits-1.5: Algae

22 Lectures

1. Systematics and Taxonomy – Principles, Concept of species and hierarchical taxa, Classification of algae up to order level as per Fritsch system (1935). 3 L
2. Algological studies – Algal habitats, Pigment constitution in algae, Reserve food, Modes of perennation in algae, Origin and evolution of sex, Contribution of algal studies in India and world (any three Phycologists). 4 L
3. Cyanophyta – Distinguishing characters, thallus organization, ultra-structure of heterocyst and its significance. 3 L
4. Chlorophyta- Thallus organization, reproduction – asexual and sexual 3 L
5. Introduction, Comparative structure and reproduction in Charophyta, Euglenophyta, Xanthophyta, Bacillariophyta and Chrysophyta. 4 L
6. Phaeophyta and Rhodophyta–Morphology, Reproduction and life cycle pattern in any one from each. 3 L
7. Applications of algae- Commercial applications of algae- Biofertilizer, Medicine, and Pollution. 2 L

Credit-1.5: Fungi

23 Lectures

1. Thallus structure, Nutrition, Cell structure, Hyphal modifications in Fungi. Classification of fungi as per Ainsworth et al system (1973), Contribution of fungal studies in India and world. 3 L
2. Myxomycotina- Distinguishing characters, types of Plasmodium and fruit bodies, Life cycle pattern 3L
3. Mastigomycotina- Distinguishing characters, Thallus structure in Chytridiomycetes and Oomycetes. 3 L
4. Zygomycotina - Distinguishing characters, Thallus structure, Heterothallism and sexual reproduction. 3 L
5. Ascomycotina- Thallus structure, Fructifications, Comparative study of Hemiascomycetes and Euascomycetes. 3 L

6. Basidiomycotina – Distinguishing characters, thallus structure, types and structure of basidia and basidiocarps. **3 L**
7. Deuteromycotina – Distinguishing characters, thallus structure, fructifications, types of conidia, conidial ontogeny. **3 L**
8. Applications of fungi- Biofertilizers, biocotrol, food and medicine. **2L**

Credit -1:Bryophytes**15 Lectures**

1. Introduction, characters, Affinities with thallophytes and pteridophytes, Contributions of bryologists in world and India (any three), Comparative system of classification according to G.M. Smith and R. M. Schuster(1972), pteridophyean and algal hypothesis, evolution of sporophyte, theory of sterilization and reduction, apogamy and apospory. **3 L**
2. Distribution, Distinguishing characters, morphology and anatomy of gametophyte and sporophytes of following orders **11 L**
Takakiales, Calobryales and Sphaerocarpaceles (1L), Marchantiales (1L),
Jungermanniales (2L), Anthocerotales (1L), Sphagnales (1L), Polytrichales (1L),
Funariales (1L), Andreaeales (1L), Eubryales (2L).
3. Applications of bryophytes- Antimicrobial properties, secondary metabolites, therapeutical, horticultural applications. **1 L**

References:**Algae:**

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14. Sharma O.P. Algae

Fungi :

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6. Mehrotra R.S. and Aneja K.R. (1990). An introduction to mycology. New Age Publishers, ISBN 8122400892.
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8. Webster J. and Rpland W. (2007). Introduction to fungi (3rd Edn) Cambridge UniversityPress,978-0-521-80739-5.

Bryophytes:

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2. Chopra R.N. and Kumar P.K. (1988).Biology of Bryophytes. John Wiley & Sons, New York, NY.
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4. Kashyap S.R. (1932). Liverworts of the Western Himalayas and the Punjab Plain (illustrated): Part 2. ChronicaBotanica, New Delhi.

5. Parihar N.S. (1980). Bryophytes: An Introduction to Embryophyta. Vol I. Central Book Depot, Allahabad.
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Semester I
BOUT 112: Botany Theory Paper II- Cell Biology
(4 Credit- 60 Lectures)

Credit-I (1 Cr): Dynamic organization of the cell 15 L

1. Universal features of cells:cell chemistry and biosynthesis, chemical organization of cells. 1L
2. Internal organization of the cell:
 - i. Cell Wall: Biogenesis, Ultra Structure and functions, primary and secondary wall, glycocalix. 1L
 - ii. Cell membrane: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells. 1L
 - iii. Biogenesis, ultra structure and functions of endoplasmic reticulum and Golgi apparatus, lysosomes, vacuoles, glyoxysomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes . 10L
 - iv. Giant chromosomes- lampbrush chromosomes, polytene chromosomes 2L

Credit-II (1 Cr): Cellular signaling, transport and trafficking 15L

1. Types of receptors, G-proteins and G-protein coupled receptors, Phospholipid signaling, Ca²⁺, Calmodulin cascade. 2L

2. Diversity in protein kinases and phosphatases, secondary messengers, regulation of signaling pathways. 2L
3. Specific signaling mechanisms with suitable examples- Biotic and abiotic stress, ABA induced stomatal closure, Stomatal guard cells signaling. 2L
4. Nuclear- organelle signaling during plastid development. 1L
5. Receptor Serine/ Threonine kinase, Ethylene mediated two component systems. 1L
6. Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior. Communication between cells and environment. 4L
7. Signaling at cell surface, signaling molecules, hormones and receptors signaling pathways that control gene activity, signal transduction and second messengers. 3 L

Credit-III (1 Cr): Cellular Processes 15L

1. Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues. 3 L
2. Phases of cell cycle, functional importance of each phase, Molecular events during cell cycle, Regulation of cell cycle, Cyclins and protein kinase, MPF (Maturation promoting factor). 3L
3. Method of study of cell cycle- labeled mitotic curve, flow cytometry, use of mutants, Cell aging and cell senescence. 3L
4. Programmed cell death-molecular aspects, regulation of cell death, PCD in response to stress, Apoptosis- Role of different genes, cell organelles during apoptosis, genetic control of apoptosis. 3L
5. Cell-ECM and cell-cell interactions; cell receptors and trans-membrane signaling; cell motility and migration 2L
6. Role of hormones and growth factors Programmed cell death Cell transformation and etiology of cancer 1L

Credit-IV (1 Cr): Genome instability and cell transformation 15L

1. Mutations, types of mutations, mutagens, proto-oncogenes, oncogenes and tumor suppressor genes, intra-genic and inter-genic suppression. 4L
2. Transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes. 4L

3. Tumor suppressor genes; structure, function and mechanism of action. 3L
4. Activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators. 4L

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20. Roy S.C and De K.K. (2005). (2nd Edition). Cell Biology, New central Book agency Private Ltd., Kolkata.
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22. Gerald Karp(2010). Cell Biology, 6th edition, John Wiley & Sons., USA
23. Geoffrey M. Cooper, Robert E. Hausman(2013)The Cell: A Molecular Approach, 6th edition, , Sinauer Associates, Inc. USA.

Semester I

BOUT 113: Botany Theory Paper III-Cytogenetics, plant breeding and evolution

(4 Credits- 60 Lectures)

Credit I (1 Cr): Classical Genetics

15 Lectures

1. Principles of Mendelian inheritance and Interaction of genes: 2 L
 - Mendel's Laws- Dominance, Segregation, Independent assortment
 - Chromosomal theory of inheritance
 - Interaction of genes- Complementary, epistasis, inhibitory, polymeric and additive
 - Concept of gene, allele, multiple alleles
2. Cytoplasmic inheritance: 3 L
 - Maternal effect (*Limanea peregra*)
 - Plastid Inheritance (*Mirabilis jalapa* and *Zea mays*)
 - Mitochondrial Inheritance (Yeast petite and Maize-Cytoplasmic male sterility)
 - Interaction between nuclear and cytoplasmic genes
3. Quantitative inheritance: 3 L
 - Multiple Factor Hypothesis, Polygenic Inheritance
 - Quantitative traits, Continuous variation
 - Inheritance of quantitative traits, (Corolla length in *Nicotiana*, Cob length in Maize)

- Heritability and its measurement
 - QTL mapping
4. Linkage, Recombination and Crossing Over: 4 L
- Linkage and crossing over
 - Linkage maps, lod score for linkage testing, mapping by 3 point test cross
 - Mapping by tetrad analysis in Yeast and *Neurospora*
 - Recombination: RecA, RecB, RecC, RecD; homologous and non-homologous
 - Somatic cell Genetics
 - Sex linkage, sex limited and sex influenced characters
5. Mutation: 3 L
- Mutation- types, causes and detection
 - Mutant type- lethal, conditional, biochemical; loss of function, gain of function
 - Germinal vs somatic mutants
 - Insertional mutagenesis, Point mutagenesis
- Credit-II (1 Cr): Microbial Genetics & Cytogenetics 15 Lectures**
1. Microbial & Phage Genetics: 4 L
- Methods of genetic transfers- transformation, conjugation and transduction in bacteria and genetic recombination
 - Mapping of bacterial genome by interrupted mating
 - Lytic and lysogenic cycles in phages, Types of transduction: Generalized and Specialized
 - Site specific recombination in phage, Mapping the bacteriophage genome
 - Fine structure analysis of rII gene in T₄ bacteriophage
2. Karyotype and Chromosome Banding: 4 L
- Preparation of chromosome for karyotype; Ideogram
 - Role of karyotype in chromosome evolution and plant species identification
 - Chromosome Banding Techniques
 - B chromosomes and Accessory chromosomes
 - Pedigree analysis
3. Numerical alterations of chromosomes: 3 L
- Aneuploids: method of production, meiotic behavior, applications

- Polyoploids: cytological and genetical method of identification of autopolyploids and allopolyploids, Applications
 - Human Genetic Disorders (Aneuploids)
4. Structural alterations of chromosomes: 3 L
- Deletion, duplication, inversion, translocation,
 - Complex translocation heterozygotes
 - Robertsonian translocations, BA translocations,
5. Introduction to Model systems in Genetics- *E.coli*, Yeast, *Drosophila*, *Arabidopsis* 1 L

Credit-III (1 Cr): Plant breeding**15 Lectures**

1. Plant Breeding: 1 L
- Concept, Objectives and applications of plant breeding,
 - Patterns of evolution in cultivated crop species
2. Plant Genetic resources: 2 L
- Centers of origin, land races, distribution and areas of diversity
 - Genetic diversity- role in crop improvement, conservation and regulation.
 - Germplasm –Types, collection and conservation
3. Methods of Plant Breeding: 3 L
- Introduction, Selection, Hybridization, Back Cross, Test Cross,
 - Mutation Breeding-
 - Reproduction, Self & cross pollination, Parthenocarpy, Apomixis,
 - Transgenics, *In vitro* Double haploids, Triploids
4. Experimental Designs of Plant Breeding and Registration of variety / hybrids 2 L
5. Selection and Hybridization methods: 3 L
- Selection methods in self and cross pollinated crops (Any one method)
 - Selection methods in asexually propagated crops
 - Inter-varietal and wide/distant crosses
 - Principles of combination breeding and its application
6. Breeding for stress tolerance 2 L
7. Plant breeding in India and abroad, Institutes-Public & Private 1 L

8. Applications of molecular markers in plant breeding 1 L

Credit-IV (1 Cr): Evolution

15 Lectures

1. Theories of Evolution: 3 L
Steps and preview of evolution, Lamarckism, Darwinism- Concepts of variation, adaption, struggle for fitness and natural selection; Neo-Darwinism, Spontaneity of mutations, the evolutionary synthesis,
2. Origin of cells and cellular evolution: 3 L
Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers, Concepts of Oparin and Halden, Experiment of Miller (1953), The first cell, evolution of prokaryote, origin of eukaryotic cells, evolution of unicellular eukaryotes, anaerobic metabolism, photosynthesis and aerobic metabolism, RNA world theory
3. Molecular Evolution: 3 L
Concepts of natural evolution, molecular clocks, molecular tools in phylogeny, classification and identification, protein and nucleotide sequence analysis, origin of new genes and proteins, gene duplication and divergence
4. Paleontology and Evolutionary History: 3 L
Evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Multicellular evolution, Major groups of plants & Animals; Fossils- Formation, Nature, Types, Geological time scale
5. The Mechanisms: 3 L
Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

REFERENCES: -

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26. Tomar & Singh Evolutionary Biology, Rastogi Publications
27. Darbeshwar Roy Crop Evolution & Genetic Resources

Semester I
BODT 114: Botany Theory paper 4-Biofertilizer and Algal Technology

(2 Credits- 30 Lectures)

Credit I (1 Cr): Biofertilizer

15 Lectures

1. Introduction, Definition, need and significance of biofertilizers in agriculture 2 L
2. Types and scope of biofertilizers: Rhizobium, Azotobactor, Azospirillum, Phosphate solubilizing microorganisms, Cyanobacteria, Azolla, Mycorrhizae. 5 L
3. Production technology: Strain selection, multiplication, sterilization, large-scale biomass production of various strains. 3 L
4. Methods of Applications: Application for field and other crops, methods of application, quality control, agronomic importance. Application methods for different biofertilizers. 4 L
5. Use of Genetically Engineered Microorganisms for improvement of biofertilizers. 1 L

Credit II (1 Cr): Algal Technology

15 Lectures

1. Introduction to Algal Technology 2 L
2. Potential of algae as food and feed, pigments, pharmaceuticals and nutraceuticals, fine chemicals and fuel. 4 L
3. Algal biofertilizers, seaweed fertilizers – method of preparation and application 2 L
4. Biodiesel from algae- cultivation and extraction methods 2 L
5. Biohydrogen production from algae. 1 L
6. Algal Products- SCP-Spirulina mass cultivation & applications, Agar production. 4 L

References:

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Semester I

BODT 114: Botany Theory paper 4- Pomoculture and Fruit Processing Technology

(2 Credits- 30 Lectures)

Credit-I (1 Cr): Introduction to Pomology

15 Lectures

1. Scope and Importance of Fruit crops, Nutritive value of fruits in human nutrition, Classification of Fruits based on : climate adaptability, fruit morphology, Botanical Classification 3L
2. Present status of fruit growing :- In India and Maharashtra, Scope of fruit growing in India and Maharashtra, Importance of fruit growing 2L
3. Planning and Lay out of orchards: Location & site, Soil, Climate, Planning, Layout: Square system, Rectangular system, Hexagonal system, Quincunx system, Contour system 2L
4. Growth & Fruiting Habits: Growth & fruiting habits, Fruit bud differentiation, fruit setting, fruit drop, Seedlessness, cracking of fruits, problems of fruiting, Bahar treatment, Unfruitfulness, Pruning and Training, role of plant growth substances. 5L
5. Methods of Propagation: Vegetative and sexual Methods of propagation of Fruit trees, its advantages & Disadvantages 3L

Credit-II (1 Cr): Fruit Processing Technology

15 Lectures

1. Harvesting: Maturity indices, Estimation of Maturity, Harvesting, Method of harvesting technology for ripening, greening, Post-Harvest Handling, Packaging, Storage 5L

2. Preservation of Fruits : 2L
Principles of Preservation, Methods of Preservation
3. Processing of Fruits : 6L
- a. Value addition:**
Preparation and preservation of Fruits: JAM, Jelly, Marmalade, Candy, Sauce & Ketchup, Pickle, fruit based carbonated juices, canning, pulp extraction, chutney, beverages like squashes, ready to serve (RTS) drinks and appetizer etc. from different fruits
- b. Fermented products:**
Production of alcoholic drinks like cider, wine, vermouth, vinegar etc is now an accepted practice for utilization of different fruits. Manufacture of champagne (sparkling wine), still wine and brandy from grapes
- c. By Product Waste Utilization:**
Pomace, Seeds, Stones/Pits skin, Peel : I) Pomace II) Vinegar Extracted from Mango peel, High fibre biscuits, Peel oil, pectin powder, peel candy and animal feed are some of the citrus peel products. Oil and fiber from oil palm.
4. Marketing of fruits: systems of marketing, export potential, air transport, transport by sea, cold storage of fruits 2L

References:

1. D. P Singh 2015. Fruit Crops : Published by Agrotech Press, Jaipur & New Delhi
2. Jitendrasingh 2014. Basic Horticulture, Published by Kalyani Publishers
3. S. N Gupta 2015. Instant Horticulture, 11th Edition, published by Jain Brothers.
4. Kunte Y. N, M. P Kawthalkar and K.S Yawalkar, 2005, Principles of Horticulture and Fruit Growing 10th edition, published by Agro-horticulture Publishing House, New Delhi
5. George Acquaah, 2009. HORTICULTURE: Principles & Practices, published by PHI Learning Pvt. Ltd.

Semester I

BODP 114: Botany practical 4 based on BODT 114 Biofertilizer and Algal Technology

Practical (2 Credits)	60 Hours
1. Study of microorganisms used in biofertilizer production	1P
2. Isolation of Nitrogen fixing cyanobacteria	1P
3. Isolation of Phosphate solubilizing micro-organisms from rhizosphere	1P
4. Isolation of Rhizobium from root nodules of leguminous crop	1P
5. Culture establishment and production of Azolla biofertilizers.	2P
6. Mass multiplication of Rhizobium, Azotobacter, and Azospirillum inoculum	2P
7. Estimation of Phycobiliproteins from Cyanobacteria	1P
8. Study of production of algal fertilizers.	1P
9. Study of any six sea weeds with applications	1P
10. Isolation and culture of <u>Spirulina</u> .	1P

Semester I

BODP 114: Botany practical 4 based on BODT 114 Pomoculture and Fruit Processing Technology

1. Study of Growth and Fruiting habit in any one locally cultivated fruit crop.	1P
2. Study of methods of Pruning and Training of fruit plants.	1P
3. Study of effect of Growth regulators in fruit ripening in Banana/Grapes/Mango.	1P
4. Study of methods of Propagation of fruit trees.	1P
5. Study Maturity indices and estimation of Maturity in locally grown Fruit plant.	1P
6. Study of Methods of Harvesting.	1P
7. Preparation of Jam, Jelly & Marmalade from Locally available fruits.	1P
8. Preparation of Squash, Candy.	1P
9. Demonstration of any one by-product of wastes of fruits.	1P
10. Visit to Fruit Processing Industry and preparation of Case study report on any one.	1P

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| 11. Visit to fruit market and prepare report. | 1P |
| 12. Visit to Vineyard preparation of case study report on Vine Industry. | 1P |

Semester I

BOUP 115: Botany practical paper based on BOUT 111, BOUT 112, and BOUT 113

Practical based on BOUT 111-Plant Systematics I

Practical on Algae:

1. Morphological observations, documentation (description and illustrations) and classification according to Fritsch (1935) with reasons of taxa belonging to:
 - a. Any one member from Charophyta, Euglenophyta, Bascilariophyta and Chrysophyta, Cyanophyta. 1 P
 - b. Any three members from Phaeophyta, Chlorophyta and Rhodophyta. 2 P

Practical on Fungi:

2. Study of the representative genera belonging to following sub-divisions of fungi with respect to vegetative, reproductive structures and classification with reasons according to Ainsworth *et al* (1973).
 - a. Any one member from each Sub-divisions: Myxomycotina, Mastigomycotina and Zygomycotina 1P
 - b. Any three members of each Sub-divisions: Ascomycotina and Basidiomycotina and Deuteromycotina. 2P

Practical on Bryophytes:

3. Morphological, anatomical and reproductive studies of the following members:
 - a. Any three members from Hepaticopsida and one member from Anthocerotopsida 1 P
 - b. Any four members from Bryopsida (Musci). 1 P

Practical based on BOUT 112: Cell Biology

- | | |
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| 4. Study of mitosis and meiosis | 2P |
| 5. Study of polytene chromosome from Chironomous larvae | 1P |
| 6. Differential centrifugation for isolation of cell fractions- Nuclear fraction | 1P |
| 7. Isolation of Chloroplasts to study | 1P |

- a. Hill reaction to measure intactness,
- b. Chlorophyll estimation
- 8. Isolation of mitochondria for: 1p
 - a. Estimation of succinic dehydrogenase activity
 - b. Microscopic observations using MitoTracker Green FM/ MitoTracker Red 580/ Janus green B
- 9. Isolation of Lysosomal fraction and estimation of acid phosphatase activity 1P
- 10. Study of induced cell senescence in leaf discs & Study of programmed cell death in plants 1P

Practical based on BOUT 113: Cytogenetics and Plant Breeding and Evolution

- 11. Karyotype analysis, preparation of C- metaphase chromosomes of appropriate material (*Allium / Aloe*). 1P
- 12. Study of Meiotic configuration and of polygenic inheritance in any suitable material 2P
- 13. Problems of population genetics: Estimation of gene and genotypic frequencies, PTC testing ability in humans, Gene mapping, *Neurospora* tetrad analysis and Analysis of F₂ data by Chi-square Test. 2P
- 14. Study of Polytene / Salivary gland Chromosomes from *Drosophilla / Chironomous* larva, with Balbiani rings, puff balls, bands & interbands. 1P
- 15. Floral Biology, Study of Pollen Viability (any two major crops). Use of Colchicine for induction of polyploidy in appropriate plant material. 1P
- 16. Study of different plant fossils & Geological Time Scale. 1P

Note: Visit to different plant diversity regions and visit to any plant breeding centre. Submission of report is Compulsory.

Semester II
BOUT 121: Botany Theory Paper 1- Plant Systematics II
(4 Credit- 60 Lectures)

Credit I (1 Cr): Pteridophytes**15 Lectures**

1. Distinguishing Characters, Classification as per Sporne System (1975), Apospory, Apogamy, Stelar evolution, Heterospory and seed habit, Contributions of Indian and world Pteridologist (any three) **3L**
2. Distribution, Distinguishing Characters, Morphology and anatomy of sporophyte and gametophyte of following orders **11L**
 Psilotales, Lycopodiales, Selaginellales, Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales and Salviniiales.
3. Applications of Pteridophytes: medicinal, horticultural, biotechnological and secondary metabolites **1L**

Credit II (1.5 Cr) Gymnosperms**22 Lectures**

1. Classification of gymnosperms by Raizada and Sahni (1960). **2 L**
2. Affinities of gymnosperms with Pteridophytes and Angiosperms. **2 L**
3. Distribution of gymnosperms worldwide and India. **1 L**
4. Economic aspects of gymnosperms **1 L**
5. General characters, morphology and affinities of **10L**
 Pteridospermales - *Glossopteris*
 Cycadeoidales - *Cycadeoidea*
 Pentoxylales - *Pentoxylon*
 Cordaitales - *Mesoxylon*
 Cycadales
 Ginkgoales
 Coniferales
 Gnetales
 Epherales
 Welwitschiales
6. Comparative account of morphology, anatomy, sporogenesis, gametogenesis, embryology, and interrelationship of Cycadales and Ginkgoales **4 L**
7. Seed development in Gymnosperms **2 L**

Credit 1.5 III Angiosperms**23 Lectures**

1. Characteristic features of angiosperms, Angiosperm as a dominant group 2 L
2. Importance and need for classification, hierarchical classification. Criteria used for classification; phases of plant classification. Overview on pre- and post-Darwinian systems of classification. 3 L
3. Phylogenetic systems of classification as per Cronquist (1981). 1 L
4. APG III system of classification. 1 L
5. Phylogeny of Angiosperms: homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades, Phylogenetic tree and cladogram, Origin and evolution of angiosperms. 3 L
6. Study of plant families with respect to general characters, morphology, economic importance and affinities following Bentham and Hooker and APG system of classification
Amborellaceae, Nymphaeaceae, Hydatellaceae, Magnoliaceae, Araceae, Arecaceae, Papaveraceae, Amaranthaceae, Leguminosae, Malvaceae, Satalaceae, Acanthaceae, Asteraceae 13 L

References:

1. Eames E.J. (1983). Morphology of Vascular Plants. Standard University Press.
2. Rashid A. (1999). An Introduction to Pteridophyta. Vikas Publishing House Pvt.Ltd. New Delhi.
3. Sporne K.R. (1986). The morphology of Pteridophytes. Hutchinson University Library, London.
4. Gangulee and Kar (2006). College Botany. New Central Book Agency
5. Smith G.M. (1955). Cryptogamic Botany Vol II. McGraw Hill.
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Semester II
BOUT 122: Botany Theory Paper II- Molecular Biology
(4 Credit- 60 Lectures)

Credit I (1 Cr): Techniques and Tools in Molecular Biology **15 Lectures**

- | | |
|---|-----|
| 1. Introduction, Scope and Applications | 1 L |
| 2. Enzymes in molecular Biology | 3 L |
| 1.1: DNA Degrading Enzymes: Nucleases- Endo-nucleases and Exo-nucleases | |
| 1.2: DNA modifying enzymes: Polymerases, Ligases, Phosphatases and polynucleotide kinases, Phosphorylase, Methylase | |
| 3. Minor equipments: | 2 L |
| Vortex, magnetic stirrer, Micropipettes, Incubator, Microfuge, microwave oven, pouch sealer and refrigerator. | |
| 4. Major equipments: | 5 L |
| PCR - Thermal Cycler, Gel Documentation System, ELISA reader, Millipore Distillation Apparatus, Lyophilizer, Refractometer, Liquid handling system and Gene sequencer | |
| 5. Molecular Techniques: | 4 L |
| 5.1. Polymerase Chain Reaction: quality of template DNA and overall reaction conditions | |
| 5.2 Sequencing Techniques: DNA sequencing 1. Sanger's dideoxy chain termination sequencing method and 2. Maxam –Gilbert sequencing method | |
| 5.3 Blotting techniques- Southern, Northern and Western blotting | |

Credit –II (1 Cr): DNA – Structure, Functions and Damage **15 Lectures**

- | | |
|---|-----|
| 1. DNA Structure, Forms of DNA (A, B, Z), Properties of DNA: chemical, physical, spectroscopic and thermal properties of DNA (e. g. Buoyant density, effect of acid and alkali, UV- absorption, hyperchromicity and hypochromicity),Dissociation and association kinetics, Cot – curve,C-value paradox. | 4 L |
| 2. Packaging of (DNA) genome e.g. Viruses, prokaryotic, eukaryotic, Organelles genome (Mitochondria and Chloroplast), structure of Nucleosome . | 4 L |

3. Replication: General factors of DNA replication, Replication apparatus, structure of DNA polymerases, Mechanism of replication in Prokaryotes and Eukaryotes, Regulation of replication and fidelity. 4 L
4. DNA damage and repair: Types of DNA damages, multiple repair pathway- Nucleotide excision repair, Base excision repair and Mismatch repair system. 3 L

Credit- III (1 Cr) Gene structure and Function**15 Lectures**

1. Gene Structure 3 L
 - a. Organization and structure of Prokaryotic and Eukaryotic gene:
 - b. Promotor, Initiater, Enhancer, Terminater, Classes of Promoter
2. Transcription 6 L
 - a. Transcription apparatus, Enzymes and factors involved in transcription
 - b. Transcription in Prokaryotes and Eukaryotes
 - c. RNA processing - m-RNA, r-RNA and t-RNA editing
 - d. Post – transcriptional events : Capping, Methylation, Polyadenylation, Splicing, Structure of spliceosome and Fidelity
3. Translation 6 L
 - a. Structure of m-RNA, r-RNA and t-RNA, Ribosomal assembly, Genetic code – Concept and Properties
 - b. Coenzymes and factors involved in translation
 - c. Mechanism of protein synthesis: Initiation, elongation and termination
 - d. Post – translational control, Protein folding and processing, Protein targeting, Chaperons and Post – translational modifications

Credit- IV (1 Cr):**15 Lectures**

1. Gene Regulation: Concept and importance , Positive and Negative regulation, Mechanism of regulation and concept: Lactose, Tryptophan and Arabinose 5 L
2. Transposable elements: Concept of Mobile DNA elements: Prokaryotes and Eukaryotes, Transposons, IS elements, SINES and LINES, Ac-Ds system in Maize, Examples of transposable elements, Importance of Transposons in Transposons mediated gene tagging. 5 L
3. Genomics and Proteomics: The human genome project: Clone by clone Strategy and Shotgun sequencing and applications of genomics, Objectives of Proteomics and Methodologies of proteomics (2D Gel Electrophoresis). 5 L

References

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Semester II

BOUT 123: Botany Theory Paper III- Biochemistry (4 Credit- 60 Lectures)

Credit-I (1 Cr): Fundamental aspects

15 Lectures

- | | |
|---|-----|
| 1. Water: Properties of water, Ionization of water | 3 L |
| 2. Buffers: pH, weak acids and weak bases, Handerson - Hasselback equation, buffers, buffer concentration & Biological Buffers. | 5 L |
| 3. Solutions: Molarity, Normality, Molality | 2 L |
| 4. Bioenergetics: Laws of Thermodynamics, free energy, energy changes, Redox reactions, chemical bonds. | 5 L |

Credit- II (1 Cr): Biomolecules

15 Lectures

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|--|-----|
| 1. Carbohydrates: General classification , structure and properties of carbohydrates, synthesis and breakdown of glucose, starch and glycogen. | 5 L |
| 2. Lipids: General classification, structure and properties of lipids, types of lipids, biosynthesis and oxidation of lipids. | 4 L |
| 3. Nucleic acids: Structure and biosynthesis of purines and pyrimidines, structure of DNA and RNA | 6 L |

Credit III (1 Cr): Protein Biochemistry

15 Lectures

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|--|-----|
| 1. Amino Acids: Classification, structure and properties of amino acids. | 2 L |
| 2. Proteins – Structure and Function, General classification, primary, secondary, tertiary and quaternary structures, Structure and function of myoglobin, keratin, haemoglobin, Ramchandran plot. | 5L |
| 3. Enzymology: General classification, mechanism of action, factors affecting enzyme activity, enzyme kinetics, Michaelis-Menton equation, competitive, non-competitive, uncompetitive inhibition. | 4L |

4. Nitrogen Metabolism: Nitrate and ammonium assimilation, nitrogen uptake, biological nitrogen fixation, NOD factors, *nif* genes, root nodulation and nitrogen fixation, leg haemoglobin. 4L

Credit-IV (1 Cr): Phytochemistry and Metabolomics**15Lectures**

1. Metabolomics: Overview of primary and secondary metabolites, integration of metabolism. 5L
2. Phytochemistry: Primary metabolites as precursors of secondary metabolites, study of secondary metabolites – structure, classification, properties and therapeutic plant sources, biosynthetic pathways - alkaloids, phenols, terpenes, glycosides, pigments. 6L
3. Phytochemical investigation: Extraction methods, qualitative and quantitative analysis of alkaloids, glycosides, terpenes, phenols, pigments. 4L

References:

1. Buchanan B. B., Gruissem W. and Jones R. L. (2000), Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Maryland, USA.
2. Dennis D. T., Turpin D. H., Lefebvre D. D. and Layzell D. B. (eds) (1997), Plant Metabolism (second edition), Longman, Essex, England.
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11. Lehninger A. L. (1987), Principles of Biochemistry, CBS Publishers and Distributors (Indian Reprint).
12. Hapse and Acharya (1999), Treaties on AgroElectronics and Agrophysics, VSI.

Semester II
BODT 124: Botany Theory paper 4- Floriculture and Nursery Management

(2 Credits- 30 Lectures)

Credit-I (Cr 1): Floriculture

15 Lectures

1. Floriculture : Concept, definition, Scope and Importance of floriculture, global scenario of flowers, scope of floriculture in India 2L
2. Pre-requisites of commercial floriculture: soil and climate requirements, field preparation, systems of planting, water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies 3L
3. Harvesting and processing of flowers: harvesting indices, harvesting techniques, postharvest handling and grading, pre cooling, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, agri-export zones 5L
4. Commercial production of flowers: varietal wealth and diversity, climate, soil preparation, aftercare and manuring, pruning and training, harvesting, yield, important pests and diseases, control measures, harvesting, grading, packing and marketing , storage and transport, export potential of cut flowers: Chrysanthemum, Gerbera, Tuberose, Anthurium; Loose flowers- Scented Rose and Jasmine 5L

Credit II (Cr 1): Nursery Management

15 Lectures

1. Introduction 1 L
2. Nursery Site: Types of Nurseries, Water, Location, Topography, Size of Nursery, Soil 2 L
3. Preparation of the Site: Clearing of surface, Removal of Top Soil, Erosion Control and Wind Damage, Surface Dressing, Shape, Fencing. 2 L
4. Design and Layout of Nursery: Administration Area, Operations Area, Production Areas, Germination Section, Transplanting Area. 2 L
5. Producing Plants from Seed: Seed Handling, Seed Procurement and Storage, Seed Dormancy and Pre-Treatment, Germination Process, Time of Sowing, Method of Sowing, Care of Seed Bed and Direct Sown Container, Transplanting the Young

- Seedlings, Light and Shade, Transplanting Natural Regeneration Seedlings, Tending the Seedlings, Watering, Germination Beds and Transplants, Weed Control. 4 L
6. Producing Plants Vegetatively: Cuttings, Air Layering, Grafting and Budding, Cleft or V Grafting, Shield or Inverted T-budding. 2 L
7. Growing Media: Growing Media for Propagation and Germination Beds, Growing Media for Transplant Beds, Growing Media for Container Seedlings, Organic Material, Compost, Mixing the Growing Media, Media Compaction in Pots, Mulching. 2 L

References:

1. Arora JS. 2006. Introductory Ornamental horticulture. Kalyani.
2. Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
3. Bose TK & Yadav LP. 1989. Commercial Flowers. NayaProkash.
4. Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. NayaProkash.
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7. Chaudhary RC. 1993. Introduction to Plant Breeding. Oxford & IBH.
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11. Keats C. Hall 2012. Manual on Nursery Practices, Forestry Department, 173 Constant Spring Road, Kingston 8, Jamaica
12. Evans Julian 1992. Plantation Forestry in the Tropics, Ch 10. Clarendon Press. Oxford.
13. Jaenicke, H. 1999. Practical Guidelines for Research Nurseries. International Centre for Research in Agroforestry. Nairobi, Kenya.
14. Mc.Donald, B. 1986. Practical Plant Propagation for Nursery Growers.
15. Schmidt, L. 2000. Guide to Handling of Tropical and Subtropical Forest Seed. DANIDA Forest Seed Centre.

Semester II
BODT 124: Botany Theory paper 4- Mushroom cultivation and Bio-pesticides

(2 Credits- 30 Lectures)

Credit-I (1 Cr): Mushroom culture

15 Lectures

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| 1. History of mushroom cultivation | 1 L |
| 2. Present status of mushroom cultivation in India and abroad | 1L |
| 3. Edible and Poisonous mushrooms | 1L |
| 4. Nutritional and medicinal values of mushrooms | 2L |
| 5. Mushrooms spawn- spawning, running and cropping | 1L |
| 6. Cultivation of paddy straw mushroom- <i>Volvariella</i> and wood mushroom- <u>Lentinus</u> . | 2L |
| 7. Cultivation of Wheat straw mushroom- <i>Pleurotus</i> | 1L |
| 8. Cultivation of Button mushroom- <i>Agaricus</i> | 2L |
| 9. Management of pest in mushroom cultivation | 1 L |
| 10. Recipes of edible mushrooms | 1 L |
| 11. World commerce of t mushrooms | 2 L |

Credit-II (1 Cr): Bio-pesticides

15 Lectures

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|--|-----|
| 1. Biological control of plant pathogens- concept and brief history | 2 L |
| 2. Antagonism- Mechanism of biocontrol- Amensalism, Predation, Parasitism | 2 L |
| 3. Applications of biological control in field- Crop rotation, irrigation, alteration of soil pH, Organic amendments, Introduction of Antagonists, Seed inoculation, Use of Mycorrhizal fungi and biofertilizers | 3 L |
| 4. Bacterial pesticides, Viral pesticides, Mycopesticides, Mycoherbicides, Mycoweedicides, Myconematicides, Insects as biocontrol agents | 3 L |
| 5. Botanical pesticides- Pyrethrum, Nicotine, Rotenone, Neem, Karanja | 3 L |
| 6. Commercialization of biopesticides | 2 L |

References

1. A Textbook of Biotechnology - R.C. Dubey

2. Biopesticides and pest management - Dhaliwal and Kaul
3. Introduction to mushroom science - T. N. Kaul
4. Beneficial fungi and their utilization - M. C. Nair
5. Beneficial fungi - S. K. Sharma
6. Mushroom cultivation - Nita Bahl

Semester II

BODP 124: Practical based on BODT 124 Floriculture and Nursery Management

Practical (2 Credits):

1. Study of methods of post harvest technology for flowers (cut flowers) 1P
2. Study of different protective structures with respect to design, components, orientation and construction for cut flower production 1P
3. Study of special cultural practices for flower crops under protected structure 1P
4. Gerbera–identification and description of species/varieties – propagation and planting –pruning management 1P
5. Study of response of micronutrients and macronutrients on growth of cut flowers. 1P
6. Preparation of project on Cut flower production including diseases and Pests management. 1P
7. Preparation of Bed for nursery 1P
8. Study of different method of seed germination 2P
9. Preparation of growing media 1P
10. Study of Grafting and budding method 1P
11. Study of Air Layering and cutting method 1P

Note: Visit to any Local Nursery and Preparation of report is compulsory

BODP 124: Practical based on BODT 124 Mushroom cultivation and bio-pesticides Practical (2 Credits):

1. Morphology of any six mushrooms 1 P
2. Preparation of spawn for mushroom cultivation 2 P
3. Cultivation of Dhingri mushroom 3 P

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|--|-----|
| 4. Any six recipes of mushroom | 2 P |
| 5. Visit to mushroom industry and report preparation | 1 P |
| 6. Any six botanical pesticides | 2 P |
| 7. Mycoherbicides- <i>Aspergillus</i> , <i>Penicillium</i> to control <i>Alternanthera</i> ,
<i>Fusarium</i> to control water hyacinth. | 2 P |
| 8. Mycofungicides- Mycorrhizal fungi to control soil borne pathogens- <i>Trichoderma</i> to control soil borne pathogens. | 2 P |

Semester II

BOUP 125: Botany practical paper based on BOUT 121, BOUT 122, and BOUT 123

(4 Cr)

Practical based on BOUT 121: Plant Systematics II

1. Studies on the families as per Bentham and Hooker's system of classification– any one example from each series available locally 4P
 Dicotyledonae:
 - a) Polypetalae: Thalamiflorae, Disciflorae, Calyciflorae
 - b) Gamopetalae: Inferae, Heteromerae, Bicarpellatae
 - c) Monochlamydae: Curvembryae, Microembryae, Unisexuales
 Monocotyledonae:
 - Epigynae, Coronariae, Calycinae, Glumaceae
2. Preparation of artificial indented or bracketed keys for identification of any four known specimen 1P
3. Study of available fossils - At least 5 specimen 1P
4. Morphological, anatomical and reproductive studies of the following with the help of live material/or herbarium specimens and/or museum specimens and/or permanent slides of the following orders: 2P
 - i) Cycadales
 - ii) Coniferales
 - iii) Gnetales

Practical Based on BOUT 122: Molecular Biology

1. Isolation and quantification of plant genomic DNA 2 P
2. Effect of temperature and alkali on absorption of DNA : hyperchromicity 1 P
3. Separation of seed storage proteins from legumes and its quantitative study and qualitative study by SDS-PAGE. 1 P
4. Electrophoretic separation of plasmid isoforms 1 P
5. Restriction digestion study of plasmid DNA and separation by Electrophoresis 2 P
6. Study of instruments or equipment's used in Molecular Biology techniques (by photographs / by power point / by Animation): PCR thermal cycler, Gel documentation system, ELISA reader, Millipore distillation apparatus, Lyophilizer, Refractometer 1 P

Practical Based on BOUT 123: Biochemistry

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| 1. Preparation of solutions and buffers. | 1P |
| 2. Thin Layer chromatography- sugars, amino acids. | 1P |
| 3. Spectrophotometry: Absorption spectra of protein and nucleic acid. | 1P |
| 4. Effect of pH and enzyme concentration on enzyme activity. | 1P |
| 5. Defatting and dialysis of proteins | 1P |
| 6. Separation of seed storage proteins by SDS PAGE | 2P |
| 7. Estimation of proteins by Lowry and Bradford Method | 1P |