University of Kalyani

M.Sc. Botany

Choice Based Credit System

Semesters I – IV Syllabus

2014 onwards

Department of Botany

Kalyani – 741235

Outline of the Choice Based Credit Semester System

Course Categories: **HC:** Hard Core; **SC:** Soft Core; **E:** Elective
Course Transaction Categories: **T:** Theory; **P:** Practical**; PW:** Project Work
Evaluation Categories: **IA:** Internal Assessment; **TEE:** Term End Examination

Course	Course Name	Points	Credit	Hrs/wk
SEMESTER I				
HARD CORE THEORY				
BOHCT1.1	Biology & Diversity of Virus, Bacteria & Fungi	75	3	4
BOHCT1.2	Biology & Diversity of Algae, Bryophytes & Pteridophytes	75	3	4
BOHCT1.3	Taxonomy of Angiosperms & Biosystematics	75	3	4
BOHCT1.4	Cytology, Cytogenetics & Genetics	75	3	4
HARD CORE PRACTICAL				
BOHCP1.1	Practical based on BOHCT1.1	25	1	3
BOHCP1.2	Practical based on BOHCT1.2	25	1	3
BOHCP1.3	Practical based on BOHCT1.3	25	1	3
BOHCP1.4	Practical based on BOHCT1.4	25	1	3
LIBRARY/ FIELD WORK/ CLASS TEST				2
Total Points & Credits in Semester I		**400**	**16**	**30**
SEMESTER II				
HARD CORE THEORY				
BOHCT2.1	Biology & Diversity of Gymnosperms, Palaeobotany & Palynology	75	3	4
BOHCT2.2	Plant Physiology and Biochemistry	75	3	4
BOHCT2.3	Plant Anatomy, Economic Botany & Pharmacognosy	75	3	4
BOHCT2.4	Plant Embryology, Plant Breeding & Biometry	75	3	4
HARD CORE PRACTICAL				
BOHCP2.1	Practical based on BOHCT2.1	25	1	3
BOHCP2.2	Practical based on BOHCT2.2	25	1	3
BOHCP2.3	Practical based on BOHCT2.3	25	1	3
BOHCP2.4	Practical based on BOHCT2.4	25	1	3
LIBRARY/ FIELD WORK/ CLASS TEST				2
Total Points & Credits in Semester II		**400**	**16**	**30**
SEMESTER III				
HARD CORE THEORY				
BOHCT3.1	Principles of Plant Pathology & Crop Protection	75	3	4
BOHCT3.2	Principles of Plant Ecology & Biodiversity, Conservation	75	3	4
BOHCT3.3	Plant Molecular Biology & Biotechnology	75	3	4

Course	Course Name	Points	Credit	Hrs/wk
SOFT CORE THEORY: Any **two** from following				
BOSCT3.1	Environmental Biology	50	2	2
BOSCT3.2	Forensic Botany	50	2	2
BOSCT3.3	Industrial Microbiology	50	2	2
BOSCT3.4	Medical Mycology	50	2	2
BOSCT3.5	Molecular Genetics	50	2	2
BOSCT3.6	Seed Physiology	50	2	2
HARD CORE PRACTICAL				
BOHCP3.1	Practical based on BOHCT3.1	25	1	3
BOHCP3.2	Practical based on BOHCT3.2	25	1	3
BOHCP3.3	Practical based on BOHCT3.3	25	1	3
Elective Course (Theory/ Practical/ Project Work)				3
LIBRARY/ FIELD WORK/ CLASS TEST				2
Total Hard Core Points/ Credits in Semester - III		**300**	**12**	**18**
Total Soft Core Points/ Credits in Semester – III		**100**	**4**	**4**
Total Points/ Credits in Semester – III		**400**	**16**	**30**
SEMESTER IV				
ELECTIVE THEORY: Elective Course allotment will be made during 3rd Semester Any **one** single combination of Course – I & Course – II from the following**-**				
BOET4.1	Genetics, Molecular Genetics, Biometry & Plant Breeding Course-I	100	4	6
BOET4.2	Genetics, Molecular Genetics, Biometry & Plant Breeding Course-II	100	4	6
BOET4.3	Microbiology Course - I	100	4	6
BOET4.4	Microbiology Course - II	100	4	6
BOET4.5	Mycology & Plant Pathology Course - I	100	4	6
BOET4.6	Mycology & Plant Pathology Course - II	100	4	6
BOET4.7	Phycology Course - I	100	4	6
BOET4.8	Phycology Course - II	100	4	6
BOET4.9	Plant Physiology, Biochemistry & Plant Molecular Biology Course - I	100	4	6
BOET4.10	Plant Physiology, Biochemistry & Plant Molecular Biology Course - II	100	4	6
BOET4.11	Pteridology & Palaeobotany Course - I	100	4	6
BOET4.12	Pteridology & Palaeobotany Course - II	100	4	6
BOET4.13	Taxonomy of Angiosperms & Biosystematics Course - I	100	4	6
BOET4.14	Taxonomy of Angiosperms & Biosystematics Course - II	100	4	6
ELECTIVE PRACTICAL				
BOEP4.1	Practical based on BOET4.1 & 4.2	75	3	8
BOEP4.2	Practical based on BOET4.3 & 4.4	75	3	8

Course	Course Name	Points	Credit	Hrs/wk
BOEP4.3	Practical based on BOET4.5 & 4.6	75	3	8
BOEP4.4	Practical based on BOET4.7 & 4.8	75	3	8
BOEP4.5	Practical based on BOET4.9 & 4.10	75	3	8
BOEP4.6	Practical based on BOET4.11 & 4.12	75	3	8
BOEP4.7	Practical based on BOET4.13 & 4.14	75	3	8
ELECTIVE COURSE PROJECT WORK				
BOEPW4.1	Project/ Review Work	25	1	4
SOFT CORE THEORY: Any **two** from following				
BOSCT4.1	Evolution	50	2	2
BOSCT4.2	Immunology	50	2	2
BOSCT4.3	Intellectual Property Rights	50	2	2
BOSCT4.4	Mycorrhiza and Mushroom Cultivation	50	2	2
BOSCT4.5	Stress Physiology	50	2	2
LIBRARY/ FIELD WORK/ CLASS TEST				2
Total Elective Course Points/ Credits in Semester - IV		**300**	**12**	**20**
Total Soft Core Points/ Credits in Semester – IV		**100**	**4**	**4**
Total Points & Credits in Semester IV		**400**	**16**	**30**
TOTAL POINTS & CREDITS		**1600**	**64**	**120**

Detailed Syllabus of the Choice Based Credit Semester System

SEMESTER – 1

Course	Subject	Points	Credits	Hrs./Wk.
BOHCT1.1	Biology & Diversity of Virus, Bacteria & Fungi	75	3	4
BOHCP1.1	Practical based on BOHCT1.1	25	1	3
TOTAL (Group A + B + C)		100	4	7

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: Group A (15 points) + Group B (15 points) + Group C (15 points)
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Virus

1. Nature and origin of virion. **(1)**
2. Nomenclature and classification, distinctive properties and of viruses, morphology (symmetry) and a general account on different kinds of viruses. Viral genome. **(2)**
3. Structure, chemistry of viruses- capsid and their arrangements, types of envelops and their composition, Molecular organization of virion with special reference to TMV and HIV. **(3)**
4. Isolation, purification and identification of viruses based on physical, chemical and immunological techniques. **(2)**
5. Transmission of plant viruses, genetic basis of cell to cell movement of plant viruses. **(2)**
6. Management of plant viruses following classical and modern technique. Satellite virus. **(2)**
7. Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even phages, lysogeny in lambda phage. **(1)**
8. Sub viral particles - prions, viroids, virusoid. **(2)**

Theory (Group B)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Bacteria

1. Scope of microbiology, Microbial taxonomy and phylogeny, major groups of Bacteria. **(1)**
2. Bacterial morphology, ultra structure of Gram positive and Gram negative bacteria. **(1)**
3. Bacterial motility, bacterial sporulation. **(1)**
4. Bacterial Growth: Kinetics, growth curve, factors affecting growth. **(1)**
5. Nutritional types: Photolithotrophs, chemolithotrophs, photoorganotrophs & chemoorganotrophs. **(1)**
6. Bacterial Genetics: Organization and replication of genetic material in bacteria – bacterial chromosome, plasmid. Recombination in bacteria - conjugation, transformation and transduction. **(2)**
7. Microbial ecology: Concept of microbial ecology with reference to air, water and soil. **(2)**
8. Food microbiology: Food borne infections and intoxications; preservation of food. **(1)**

9. Immunology: Cells and organs of immune system, types, antigen (chemical nature and types), immunoglobulins (structure and types), brief idea about hypersensitivity and vaccine. **(2)**

10. Medical Microbiology: Air, water, food and soil borne diseases - causal organisms, symptoms, control. **(1)**

11. Industrial microbiology: Industrial production of ethanol, penicillin and vitamin B12. **(1)**

12. Cosmetic microbiology: Current trends **(1)**

Theory (Group C)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Fungi and Lichens

1. Distinctive features of fungi to form a separate kingdom; modern trends in classification. **(1)**

2. The architecture of fungal cell, cell wall, cell membrane, cell organelles and cytoskeleton, nucleus and its division; biogenesis and protoplast technology; translocation in mycelia. **(2)**

3. Genome organization in fungi; extra chromosomal and transposable genetic elements in fungi. **(1)**

4. Somatic recombination in fungi: heterothallism; heterokaryosis and parasexuality. **(1)**

5. Diversity of somatic, reproductive and fruiting structures in different groups of fungi: Myxomycotina, Mastigomycotina (with special reference to sex hormones), Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina (special emphasis on conidial ontogeny) **(9)**

6. Lichens: types, reproduction, nature of symbiosis, ecology and succession. **(1)**

Practical Course: BOHCP1.1 (Based on BOHCT1.1 – Biology & Diversity of Virus, Bacteria & Fungi)

Points: 15 **3 hours/ week**

1. Study of symptoms of diseases of economically important plants caused by virus.

2. Study of inclusion bodies in virus infected plants, its distribution and orientation.

3. Study of epidermal pattern of virus infected leaves with reference to change in stomatal index.

4. Biochemical study of detection of plant viruses.

5. Field record of herbarium sheets of virus infected plants must be submitted

6. Isolation and enumeration of bacteria from soils and water samples

7. Enrichment and Isolation of free-living nitrogen fixing bacteria from soil

8. Isolation and staining of *Rhizobium* from root nodule

9. Determination of antibiotic sensitivity of some bacteria by disc diffusion method

10. Determination of thermal death point of Bacteria

11. Turbidity estimation of bacterial growth, construction of bacterial growth curve; Influence of inhibitor on bacterial growth.

12. Study of morphological and reproductive structures of some macro- and micro-fungi

13. Identification of different fruiting structures of macro-fungi, permanent slides with different reproductive structures of micro-fungi, spore forms of rust fungi, lichens

Note: Regularly checked Laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of TEE.

Course	Subject	Points	Credits	Hrs./Wk.
BOHCT1.2	Biology & Diversity of Algae, Bryophytes & Pteridophytes	75	3	4
BOHCP1.2	Practical based on BOHCT1.2	25	1	3
TOTAL (Group A + B + C)		100	4	7

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: Group A (15 points) + Group B (15 points) + Group C (15 points)
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Algae

1. Modern trends: Outline of principles and recent trends in algal systematics; endosymbiotic theory of chloroplast evolution and algal origin. **(2)**
2. General overview & Resource utilization: Prochlorophyta; Glaucophyta; Dinophyta; Heterokontophyta: Bacillariophyceae, Xanthophyceae, Eustigmatophyceae; Bio-fertilizers and bio-molecules with commercial application. **(5)**
3. Cyanobacteria: Diversity of forms and habitats; cyanobacterial taxonomy; cyanobacterial evolution; cyanobacterial genetics. **(3)**
4. Rhodophyta: Diversity of forms and habitats; evolutionary trends in red algae; ecology of red algae. **(2)**
5. Chlorophyta: Diversity of forms and habitats; evolutionary trends of green algal lineages; salient features of different classes of chlorophytes. **(2)**
6. Phytoplankton: Types of phytoplankton; algal blooms; algal toxins **(1)**

Theory (Group B)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Bryophytes

1. General classification: Criteria, recent trends and outline of classification of the liverworts, mosses and hornworts. **(6)**
2. Phylogeny: Evolutionary significance and interrelationships; recent concepts on evolution of the three lineages (liverworts, mosses and hornworts). **(4)**
3. Ecological significance of Bryophytes: Range of substrates of bryophytes; chemical specialists; population and community dynamics of bryophytes; adaptations in bryophytes; ecological roles of bryophytes. **(3)**
4. Conservation aspects: Levels of threats; vulnerability; conservation strategies; restoration. **(2)**

Theory (Group C)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Pteridophytes

1. Introduction: Diagnostic properties of pteridophytes; an outline of recent system of classification of Pteridophytes upto order level with characteristic features. **(2)**

2. Diversity and Evolution: Diversity in organography and the evolutionary trends in the members of Psilophyta, Lycophyta, Sphenophyta and Filicophyta - Early ferns, Eusporangiate ferns (Ophioglossales, Marattiales), Leptosporangiate ferns (Filicales, Marsileales, Salviniales). **(5)**
3. Gametophyte: Morphology; gametophytic phase; patterns of spore germination; patterns of gametophyte development in homosporous and heterosporous pteridophytes; gametangia; gametes; fertilization process; mating systems; embryology. **(3)**
4. Sporophyte: Shoot apex; stelar organization; occurrence of vessels and secondary growth; root; leaf; sporangium and sporophyll; evolution of sorus in ferns; mature sporangium. **(3)**
5. Cytogenetics and Speciations: Pteridophytes with low and high chromosome number; polyploidy in microphyllous and megaphyllus forms; intergeneric and interspecific hybridity; obligate interbreeding forms. **(1)**
6. Environment, Habitat, Conservation: Environment and habitat of modern pteridophytes; endangered and endemic pteridophytes and their conservation. **(1)**

Practical Course: BOHCP1.2 (Based on BOHCT1.2 – Biology & Diversity of Algae, Bryophytes & Pteridophytes)

Points: 15 **3 hours/ week**

1. Morphological study and identification of members of the major algal groups – Cyanobacteria, Rhodophyta and Chlorophyta.
2. Seaweed identification – *Enteromorpha, Ulva, Catenella, Padina* and *Sargassum.*
3. Phytoplankton sampling for qualitative and quantitative studies.
4. Collection of algae from different localities and through local tours; their preservation and identification.
5. Field record, collection and preservation of common algal taxa.
6. Morphological study and identification of members of the three lineages – Marchantiophyta, Bryophyta and Anthocerotophyta.
7. Identification of diagnostic features of preserved bryophytic specimens and permanent slides.
8. Collection of bryophytes from different localities and through local tours; their preservation and identification.
9. Field record, collection and preservation of common bryophyte taxa.
10. Comparative morpho-anatomical studies of vegetative and reproductive organs of some members of available pteridophytes with identification up to generic level.
11. Study of diagnostic features of important pteridophytic taxa .
12. Field record, collection and preservation of common pteridophytic taxa.

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, specimens collected during compulsory field works (preferably one long field visit) should be submitted in a standard manner along with Field Note Books at the time of TEE.

Course	Subject	Points	Credits	Hrs./Wk.
BOHCT1.3	**Taxonomy of Angiosperms and Biosystematics**	**75**	**3**	**4**
BOHCP1.3	**Practical based on BOHCT1.3**	**25**	**1**	**3**
TOTAL		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: **Internal Assessment (30) + Term End Examination (45)**
TEE: 45 points
PRACTICAL: **Internal Assessment (10) + Term End Examination (15)**

Theory

Points: 45 **Classes/ Semester: 45**

Taxonomy of Angiosperms & Biosystematics

1. Systems of angiosperms classification: Outline of classification of Cronquist (1988) and Takhtajan (1997) up to Subclasses / Super orders. Broad outline of angiosperm phylogeny Group (APG) III, 2009 with the outline concept of Palaeoherbs and Eudicots. **(5)**

2. A general survey of the following taxa of angiosperms (*sensu* Cronquiust, 1988) with reference to their characteristics, inter-relationship, evolutionary trends, changed concepts and economic importance in the light of recent researches: Amborellaceae, Magnoliales, Caryophyllidae, Nepenthales, Podostemales, Asterales, Alismatales and Poaceae. **(10)**

3. ICBN : Changes, addition and alteration of latest four codes; principles, rank of taxa and names of taxa, nomenclatural types, priority of publication and limitation of the priority of publications, effective and valid publications, author's citation; changes and rejection of names, preliminary concept of appendices. Principle idea about Bio-codes and Phylocodes. **(5)**

4. Concepts of phytogeography: Endemism in India; invasion and introduction of plants in India. **(3)**

5. Botanic Gardens and Herbaria: Importance, examples from India and abroad. **(2)**

6. Biosystematics: Definition, methods, categories, differences with classical taxonomy. **(3)**

7. Numerical Taxonomy: Definition, principles, logical steps, applications, merits and demerits. **(3)**

8. Evolutionary concept ; Basic idea about following terms - Plagiomorphy and Apomorphy; Parallelism and Convergence; Homology and Analogy; Monophyly and Polyphyly including the concept of Heterobathmy, Cline, Polarity, Anagenesis and Cladogenesis, Symplesiomorphy, Synapomorphy, Autopomorphy, Stasigenesis, Catagenesis, Paraphyly, Holophyly, Homoplasy; Phylogram, Dendrogram and Cladogram. **(3)**

9. Cladistics system of classifications of Angiosperms: Principles, methods, merits and demerits. **(2)**

10. Data sources of taxonomy: Embryology, photochemistry with brief account of DNA - Taxonomy, DNA - barcoding, e - Taxonomy; nuclear rDNA, chloroplast and mitochondrial DNA; ultrastructure of sieve tube plastids. **(6)**

11. Taxonomic literatures: Definitions with examples of classical books, index, flora and manual, revision and monograph, icons, bibliography, catalogue, encyclopedias, glossary and dictionary. Important periodicals of India and abroad. **(3)**

Practical Course: BOHCP1.3 (Based on BOHCT1.3 – Taxonomy of Angiosperms & Biosystematics)
Points: 15 **3 hours/ week**

1. Drawing and description of specimens from representative locally available families.
2. Identification of family with the help of Keys of angiosperms by Davis and Cullen's book and Hutchinson's book.
3. Identification of genera and species with the help of local and regional floras.
4. Preparation of an artificial indented /bracketed key at family/generic/ species level, from locally available plants as well as, from the worked out plants.
5. Two compulsory local field excursions for familiarization with the local flora.
6. Herbarium specimens (at least 25) of wild plants abundant in the locality to be submitted at the term-end examination.

Note: Regularly checked laboratory records and specimens collected during compulsory field works should be submitted in a standard manner along with Field Note Books at the time of TEE.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT1.4	**Cytology, Cytogenetics & Genetics**	**75**	**3**	**4**
BOHCP1.4	**Practical based on BOHCT1.4**	**25**	**1**	**3**
TOTAL		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: **Internal Assessment (30) + Term End Examination (45)**
TEE: 45 points
PRACTICAL: **Internal Assessment (10) + Term End Examination (15)**

Theory

Points: 45 **Classes/ Semester: 45**

Cytology, Cytogenetics & Genetics

1. Genome organization in Eukaryotes: DNA packing in nucleosome; repetitive, satellite and unique DNA sequences; C-value paradox; structural and functional organization of telomeres and centromeres; spindle organization, polymerization and significance. **(3)**
2. Karyotype concept in relation to evolution; banding techniques; GISH and FISH techniques. **(3)**
3. Sex determination: Sex determination in plants and their interrelationship with human, *Drosophila* and mice models; dosage compensation; sex linked inheritance. **(4)**
4. Special type chromosomes: Cytogenetical significance of polytene and B-chromosome; deletion mapping; recombination. **(2)**
5. Linkage and crossing over: chiasma frequency and genetic map distance; Evolutionary significance of recombination; tetrad analysis; centromere mapping with ordered tetrad. **(4)**
6. Reciprocal translocation: Cytogenetics of reciprocal translocation in plant species; Gaudens and Velans complex; reciprocal translocation in humans. **(2)**

7. Polyploidy: Polyploids and aneuploids; Inheritance of autopolyploids and trisomics; significance and limitations of polyploidy; aneuploidy in humans. **(4)**

8. Plastids and mitochondrial DNA influenced traits. **(2)**

9. Microbial genetics: Transformation, conjugation and transduction and their significance in gene mapping. **(2)**

10. Gene mutation: Induction, types, molecular basis, significance; paramutation; DNA repair mechanism; epigenetic changes; genetic imprinting; prion particles; site directed mutagenesis; gene complementation test; rII locus. **(5)**

11. Biology of DNA and RNA: DNA forms; DNA replication; transcription and translation processes; RNA types; characterization of rRNA; pre mRNA processing. **(4)**

12. Genetic regulation: Regulation of prokaryotic gene expression – *lac*, *trp* and *ara* operons; regulation of eukaryotic gene expression – brief account. **(3)**

13. Transposomal elements: Ac-Ds, IS elements, P-elements and their role in genetics. **(2)**

14. Population genetics: Hardy-Weinberg principle; gene frequency in a population, genetic equilibrium, factors affecting gene frequency. **(2)**

15. Cell cycle regulation and cancer: Role of proteins in controlling cell cycle; apoptosis; oncogenes and protooncogenes; tumour suppressor genes; role of E2F and p^{53} in controlling cell cycle; cancer therapy. **(4)**

16. Recombinant DNA technology – brief account **(2)**

Practical Course: BOHCP1.4 (Based on BOHCT1.4 – Cytology, Cytogenetics & Genetics)

Points: 15 **3 hours/ week**

1. Concept of karyotype analysis; karyotype analysis and ideogram preparation.

2. Determination of chiasma frequency.

3. Pollen mitosis – *Allium cepa*.

4. Determination of nucleolar frequency in a plant specimen?

5. Determination of mitotic index in a plant species.

6. Study of sex chromatin in cell population.

7. Determination of gene/allelic frequency from ABO blood group in human population.

8. Pollen fertility and viability analysis.

9. Localization of DNA *in situ*.

10. Testing goodness of fit from the supplied samples.

11. Reciprocal translocation and inversion heterozygosity (demonstration).

12. Macromutation and polyploidy (demonstration).

13. Protein and DNA separation by gel electrophoresis (demonstration).

Note: Regularly checked laboratory records, permanent slides prepared during practical classes should be submitted in a proper way at the time of TEE.

SEMESTER – 2

Course	Subject	Points	Credits	Hrs./Wk.
BOHCT2.1	Biology & Diversity of Gymnosperms, Palaeobotany & Palynology	75	3	4
BOHCP2.1	Practical based on BOHCT2.1	25	1	3
TOTAL (Group A + B + C)		100	4	7

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: Group A (15 points) + Group B (15 points) + Group C (15 points)
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 15 **Classes/ Semester: 15**

Biology & Diversity of Gymnosperms

1. Introduction: General morphology of gymnosperms; classification of gymnosperm; brief review of phylogenetic systems in gymnosperms; current concepts on classification with ordinal features. **(2)**

2. Palaeozoic Pteridosperms (Seed Ferns): Major events in evolution of Palaeozoic Pteridosperms; brief account of Lyginopteridaceae, Calamopityaceae, Medullosaceae, Callistophytaceae. **(3)**

3. Cycads & Cycadeoids: General traits, circumscriptions of the families of Cycads, early evidence, Cycad and Cyadeoid foliage. **(2)**

4. More Gymnosperm Diversity: Brief account of Caytoniaceae, Corystospermaceae, Peltaspermaceae, Glossopteridceae, Pentoxylaceae. **(3)**

5. Ginkgos: General traits, early evidence, distribution in time and space. **(1)**

6. Conifers: General traits of conifers; first evidence of conifer organization - Cordaitales, Voltziales; origin of conifer cones and leaves; circumscriptions of the families of extant conifers and their interrelationships; comparative account among conifers on basis of the male gametophyte, pollination mechanisms, female gametophytes, proembryo development. **(3)**

7. Gnetophytes: General traits; characteristics features of the genera of Gnetopsida; comparisons amongst *Ephedra*, *Gnetum* and *Welwitschia.* **(1)**

Theory (Group B)

Points: 15 **Classes/ Semester: 15**

Palaeobotany

1. Introduction: Definition and application. **(2)**

2. Preservation of plants as fossils: Definition; taphonomy; environment for fossilization; modes of preservation; types; major rock types, rock cycle and rocks containing Fossils; systematics, reconstruction and nomenclature. **(2)**

3. Geologic Time: Geologic timescale, relative *vs*. numerical age, physical and biological principles for defining relative and numerical age. **(1)**

4. Early Life: The origin of earth, earliest environment, theories on origin of life, evidences for the origin of life - prokaryotes, evolution of eukaryotes and fossil records, diversified life - algae and fungi. **(3)**

5. Terrestrialization of plants: Geologic time, environment, vegetative and reproductive adaptations to land dwelling, fossil evidences - transitional plants with land adaptive features, early non vascular land plants (bryophytes), early vascular land plants (pteridophytes). **(2)**

6. Early vascular plants to early spore producing trees (arborescent pteridophytes & progymnosperms): Geologic time, environment, advancement in plant adaptive features for land dwelling with fossil evidences. **(2)**

7. Early spore producing trees to early seed producing trees (gymnosperms): From isospores to free sporing heterospores, origin of ovule, hydrasperman reproduction with fossil evidences. **(1)**

8. Origin and evolution of flowering plants (angiosperms): Geologic time, evolutionary trends **- a**ngiosperm derived characteristics, fossil evidences for early flowering plants, place of origin, radiation, phylogeny. **(2)**

Theory (Group C)

Points: 15 **Classes/ Semester: 15**

Palynology

1. Spore-pollen morphology: units, polarity, symmetry, shape, size, aperture; NPC system for numerical expression of apertural details; harmomegathic mechanism; evolution of aperture types. **(3)**

2. Sporoderm: stratification & sculptures; LO- analysis; pollen wall evolution. **(1)**

3. Pollen Wall: Development; Ubisch body; sporopollenin; adaptive significance of pollen wall architecture. **(2)**

4. Extraexinous wall materials: pollen connecting threads, perine, pollen-kitt. **(2)**

5. Natural spore/pollen traps: Types, their implications in floristic & environment reconstruction. **(2)**

6. Branches of Palynology & their Application: Branches of palynology; palynology in taxonomic & phylogenetic deductions; palynology in academic & applied aspects including melissopalynology, medical palynology, forensic palynology, entomopalynology & copropalynology. **(5)**

Practical Course: BOHCP2.1 (Based on BOHCT2.1 – Biology & Diversity of Gymnosperms, Palaeobotany and Palynology)

Points: 15 **3 hours/ week**

1. Studies of morpho-anatomy of conifer leaves and their identification (at least five taxa).
2. Studies of reproductive structures of at least two conifers.
3. Characterization of at least four taxa of gymnosperms for identification.
4. Studies of morpho-anatomy of *Gnetum* and *Ephedra*.
5. Field record and plant collection to be submitted (not more than 10 herbarium specimens).
6. Studies of types of fossils, modes of preservation, rocks and tectonic features of rocks.
7. Systematic studies of available plants fossils through ages.
8. Demonstration of extraction of microfossils from peat, lignite and coal samples, quantitative and qualitative palaeopalynological study of macerated peat, lignite and coal samples and interpretation of data on stratigraphic age and environment of deposition.

9. Preparation of palynological slides by acetolysis method from fresh and dry spore and pollen samples.
10. Studies of different types of spores (pteridophyte) and pollen grains (gymnosperms and angiosperms), their shape, aperture and sculpture.
11. Preparation of honey samples and its characterization for melittopalynological study.
12. Preparation of natural spore-pollen traps (at least two) for palynology.

Note: Regularly checked laboratory records, specimens collected during compulsory field works and permanent slides prepared during practical classes should be submitted in a standard manner along with Field Note Books at the time of TEE.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT2.2	**Plant Physiology and Biochemistry**	**75**	**3**	**4**
BOHCP2.2	**Practical based on BOHCT2.2**	**25**	**1**	**3**
TOTAL (Group A + B)		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: 45 points
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory

Points: 45 **Classes/ Semester: 45**

Plant Physiology & Biochemistry

1. Water and Plant Cells : Water in Plant life, structure and properties of water, water potential-chemical properties of water, water potential of Plant Cells, major factors contributing cell water potential, cell wall and membrane properties. **(2)**

2. Water balance of Plants: Water in the Soil, Water absorption by roots, Water transport through Xylem, Water movement from leaf to atmosphere, Soil-Plant-atmosphere continuum. **(2)**

3. Solute Transport and photo assimilate translocation: transport of ions, membrane barriers, membrane transport process, transport proteins, Ion transport in roots, and mechanism of loading and unloading of photoassimilates. **(4)**

4. Signal transduction: Signal transduction in prokaryotes and eukaryotes, signal transduction in space and time. **(3)**

5. Sensory photobiology: Light control of plant development; phytochrome: properties, phytochrome induced response, phytochrome signalling pathways, blue light responses; photophysiology and photoreactions. **(3)**

6. Growth and developmental physiology : Seed germination and seedling growth, metabolism of nucleic acids, proteins, mobilization of food reserves, hormonal control of seedling growth; Chemistry, biosynthesis ,developmental and physiological effects, signal cascade modes of action of auxins, gibberellin, cytokinin, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonates. **(4)**

7. Senescence and programmed cell death: types of senescence, metabolic changes associated with senescence and its regulation, influence of hormones, environmental features of senescence. **(2)**

8. Control of flowering: Floral meristem and floral organ development, modern concept. **(3)**

9. Stress physiology: Response and adaptation to abiotic stress: water stress, temperature stress (heat and cold stress), stress induced gene expression. **(3)**

10. Principle of biophysical chemistry: pH, buffer, reaction kinetics, thermodynamics, law of mass action, acid base reactions, bond energy, energy rich compounds, redox potential, free energy. **(4)**

11. Enzyme: Enzyme kinetics, catalytic reactions and regulatory properties, inhibitions, iso-enzymes, allosterism, ribozyme and abzymes. **(2)**

12. Chemistry and plant products: structure and properties of carbohydrates, lipids, amino acids, proteins, nucleic acids, vitamins and co-enzymes. **(3)**

13. Photosynthesis: Light reactions, structure of photosynthetic apparatus, organization of light absorbing antenna system, mechanism of electron and proton transport, carbon reactions: C_3, C_4, C_2, C_1 (algal and cyanobacterial pump) and CAM. **(3)**

14. Respiration and lipid metabolism: Glycolysis, Citric acid cycle, plant mitochondrial electron transport, ATP synthesis, PPP cycle, regulation of respiration by metabolites, alternative oxidase, fatty acid biosynthesis and degradation. **(3)**

15. Nitrogen metabolism: Biological and non biological nitrogen fixation, nitrate and ammonium assimilation. **(3)**

16. Regulation of metabolism. **(1)**

Practical Course: BOHCP2.2 (Based on BOHCT2.2 – Plant Physiology & Biochemistry)

Points: 15 **3 hours/ week**

1. Estimation of sulphur and calcium.
2. Estimation of reducing sugar.
3. Effect of substrate concentration on enzyme activity and determination of K_m.
4. Effect of temperature and pH on enzyme activity.
5. Study of invertase, diastase and urease activity.
6. Measurement of water potential of plant tissue.
7. Extraction of fat by Soxhlet's apparatus.
8. Determination of acid value and saponification value of fat.
9. Induction of α-amylase synthesis in aleurone cells of rice grains by GA_3.
10. Paper chromatography of amino acids.
11. Separation of pigments by column chromatography.
12. Estimation of CO_2 release in aerobic respiration.
13. Effect of uncoupler on rate of respiration.
14. Study of Hill reaction in isolated chloroplast.
15. Effect of antitranspirant on the rate of transpiration.

Note: Regularly checked laboratory records should be submitted in a standard manner at the time of TEE.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT2.3	Plant Anatomy, Economic Botany & Pharmacognosy	75	3	4
BOHCP2.3	Practical based on BOHCT2.3	25	1	3
TOTAL (Group A + B)		100	4	7

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: Group A (15 points) + Group B (15 points) + Group C (15 points)
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 15 **Classes/ Semester: 15**

Plant Anatomy

1. Overview of plant structure: cell types; tissue types and their arrangement; phylogenetic and ontogentic development and organization of shoot and root apical meristems. **(3)**
2. Epidermis: stomatal ontogeny; cuticle: structure, function and commercial uses; trichome types. **(3)**
3. Conducting Tissues: Xylem: ontogeny, phylogeny and evolution of tracheary elements and fibres; ray parenchyma and axial parenchyma. Phloem: ontogeny and evolution. Transfer cells. **(5)**
4. Secretory structures: internal secretory structures – laticiferous tissue system, secretory cavities and ducts; external secretory structures – hydathodes, nectaries, salt glands and colleters; economic importance of plant secretions. **(2)**
5. Ecological anatomy: wood development in relation to environment. **(2)**

Theory (Group B)

Points: 15 **Classes/ Semester: 15**

Economic Botany

1. Centre of origin of cultivated plants; Indian centre of wild plant genetic resources. Botany and uses of fodder, fiber yielding, medicinal and aromatic plants. **(2)**
2. An accounts and uses of the following plant resources: Timber, non-wood forest products, bamboo and cane; paper yielding plants; sources of following plant products - resin, gum, tannin, dye, rubber and latex. **(6)**
3. Non - medicinal poisonous and toxic plants: Preliminary accounts of the plants and their effect: hallucinogenic, allergenic, teratogenic and carcinogenic. **(3)**
4. Bioprospecting: antimicrobial, antifungal, antiviral and anti-cancerous plants. **(2)**
5. Plants used for pollution control: Methods of control and examples. Mineral indicating plants. **(2)**

Theory (Group C)

Points: 15 **Classes/ Semester: 15**

Pharmacognosy

1. Pharmacognosy: Definition and scope. **(1)**
2. Pharmacopoeias: Definition and examples. **(1)**
3. Classification of plant drugs: Morphological and chemical (brief knowledge of different categories of drug plants producing carbohydrates, alkaloids, essential oils, resins and glycosides). **(4)**

4. Concise account of macro - micro morphological features, constituents, adulterants, allied drugs and uses of the following plants - *Digitalis* (leaf drug); *Cinchona* (bark drug); *Cephaelis* (root and rhizome drugs); *Rauvolfia* (root and rhizome drugs); *Strychnos* (seed drug); *Syzygium* (flower drug) and *Coriandrum* (fruit drug). **(9)**

Practical Course: BOHCP2.3 (Based on BOHCT2.3 – Plant Anatomy, Economic Botany & Pharmacognosy)

Points: 15 **3 hours/ week**

1. Systematic study of trichomes.

2. Study of different types of stomata.

3. Computing palisade ratio.

4. Study of laticiferous ducts/ cells.

5. Study of anatomy of xeromorphic and succulent leaves.

6. Organoleptic and microscopic evaluation of the following drug plants:

a. *Datura /Adhatoda /Azadirachta* (Leaf drug)

b. *Zingiber / Cephaelis* (Rhizome & Root drug)

c. *Syzygium* (Flower drug)

d. *Coriandrum/Trachyspermum/ Foeniculum/Cuminum* (Fruit drug)

e. *Strychnos* (Seed drug)

7. Study of starch grains from different plant sources.

8. One field trip to become familiar with economically important plants and their respective uses. Enlistment of the studied plants should be submitted.

Note: Regularly checked laboratory records and specimens enlisted during compulsory field works should be submitted in a standard manner along with Field Note Books at the time of TEE.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT2.4	**Plant Embryology, Plant Breeding & Biometry**	**75**	**3**	**4**
BOHCP2.4	**Practical based on BOHCT2.4**	**25**	**1**	**3**
TOTAL (Group A + B)		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: **Internal Assessment (30) + Term End Examination (45)**
TEE: Group A (15 points) + Group B (30 points)
PRACTICAL: **Internal Assessment (10) + Term End Examination (15)**

Theory (Group A)

Points: 15 **Classes/ Semester: 15**

Plant Embryology

1. Plant development: Concept, definition and unique features of development in plants. **(2)**

2. Transition from vegetative to reproductive phase: morpho-histochemical changes in shoot apex floral meristem and floral organ development in *Arabidopsis*. **(2)**

3. Molecular genetics in Plant Development: Techniques of studying plant developmental pattern: Mutants and transgenics in plant development. **(2)**

4. Gametogenesis fertilization and early development:

i. Development of stamen, anther, sporogenous tissue, microspores, pollen and male germ unit. Molecular basis of male gametophyte development. **(2)**

ii. Development of carpel, ovule, megaspore, female gametophyte and female germ unit. Molecular basis of female gametophyte development. **(2)**

iii. Genetic and molecular basis of self incompatibility. Fertilization, double fertilization, triple fusion, imprinting and endosperm development in gymnosperms and angiosperms, embryogenesis in gymnosperms and angiosperms, establishment of symmetry in plants, seed formation. **(3)**

5. Developmental routes of apomixis, polyembryony and its molecular aspects. **(2)**

Theory (Group B)

Points: 30 **Classes/ Semester: 30**

Plant Breeding & Biometry

1. Breeding methods: Introduction and conservation of germplasm, mass selection, pure line selection, clonal selection, hybridization, selection after hybridization (bulk, pedigree, recurrent), heterosis & inbreeding depression. **(2)**
2. An outline of mutation and polyploid breeding. **(2)**
3. Cytogenetics & breeding practices of crop plants: rice, maize, potato **(3)**
4. An outline of breeding methods for development of disease resistance **(2)**
5. Molecular marker assisted breeding – an outline **(1)**
6. Population samples, sampling methods. **(1)**
7. Frequency distribution, histogram, normal curve, mean, median, mode, variance, standard deviation, standard error. **(2)**
8. Probability & test of significance (Student & paired t) χ^2 test (detection of segregation ratio & linkage, test of independence & heterogeneity), analysis of variance (F test) CD, genetic advance, heritability estimation. **(10)**
9. Correlation & regression. **(4)**
10. Design of experiments: general principles of field trails, randomized blocks, latin square, split plot designs, layout of breeding experiment. **(3)**

Practical Course: BOHCP2.4 (Based on BOHCT2.4 – Plant Embryology, Plant Breeding & Biometry)

Points: 15 **3 hours/ week**

1. Microsporogenesis and development of male gamephyte (pollen) and pollinia.
2. Megasporogenesis and development of female gametophyte.
3. Observation on types of endosperm, dissection and isolation of endosperm.
4. Observation or stages of embryo development, dissection and isolation of developing embryo.

5. Effect of different concentration and combination of sucrose, boric acid on pollen germination and pollen tube growth.
6. Pollen-pistil interaction in angiosperms.
7. Hybridization technique (anthesis, emasculation, pollination).
8. Studies on genetic variability in crop plants utilizing biometrical approaches t-test, F analysis, distribution patterns.
9. Designing of breeding experiments.
10. Determination of genetic segregation involved qualitative traits in plants.
11. Correlation and regression analysis for yield contributing traits in crop plants.
12. Seed germinability and viability test.

Note: Regularly checked laboratory records should be submitted in a standard manner at the time of TEE.

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SEMESTER – 3

Course	Subject	Points	Credits	Hrs./Wk.
BOHCT3.1	**Principles of Plant Pathology & Crop Protection**	**75**	**3**	**4**
BOHCP3.1	**Practical based on BOHCT3.1**	**25**	**1**	**3**
TOTAL (Group A + B)		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: 45 points
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 45 **Classes/ Semester: 45**

Principles of Plant Pathology & Crop Protection

1. Historical and developmental aspects of plant pathology. **(2)**
2. Production, liberation and dispersal of inoculum, inoculum potential; factors affecting inoculum potential. **(3)**
3. Host-pathogen interaction: penetration and disease development, role of cell-wall degrading enzymes and toxins, recognition mechanism and signal transduction during plant-pathogen interaction. **(8)**
4. Defense mechanisms of plants against infection: Preexisting structural and biochemical defense, induced structural and biochemical defense, hypersensitive reaction, phytoalexins, PR proteins, systemic acquired resistance, induced systemic resistance; Gene for gene hypothesis; concept of horizontal and vertical resistance. **(10)**
5. Physiological (photosynthesis, respiration, translocation of water and nutrients) and molecular (protein and nucleic acid) changes in diseased plants. **(5)**
6. Predisposition, survival of pathogen in nature and its spread, disease epidemics. **(2)**
7. Principles of plant disease control: exclusion, eradication, protection and therapy. **(2)**
8. Strategies of plant disease management with special emphasis on cultural and biological management; plant quarantine; integrated pest management. **(2)**
9. Fungicides: types and uses. **(1)**
10. Study of some plant diseases with reference to symptoms, etiology and control measures: **(10)**
    i. Fungal diseases: wart and early blight of potato, downy mildew of grapes, powdery mildew of rose, white rust of crucifers, peach leaf curl, linseed rust, smut and red rot of sugarcane, Tikka disease of groundnut, Panama disease (Fusarium wilt) of banana, blast and sheath blight of paddy.
    ii. Bacterial diseases: leaf blight of paddy, Moko disease (bacterial wilt) of banana.
    iii. Viral diseases: Tungro viral disease of paddy, mosaic of potato.
    iv. Disease caused by nematode: root knot of tomato.
    v. Disease caused by mycoplasma-like organism: little leaf of brinjal.

Practical Course: BOHCP3.1 (Based on BOHCT3.1 – Principles of Plant Pathology & Crop Protection)

Points: 15 **3 hours/ week**

1. Sterilization and incubation: principles and uses of instruments
2. Culture media and their preparation
3. Preparation of stabs, slants and pouring of plates
4. Isolation of pathogen from diseased tissues (leaf, stem and fruit) and their culture
5. Preparation of pure culture and sub-culturing
6. Inoculation of tuber, stem and fruit
7. Assay of pre-existing toxic compounds in host plant
8. Measurement of enzyme activity in pathogen
9. Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT3.2	**Plant Molecular Biology & Biotechnology**	**75**	**3**	**4**
BOHCP3.2	**Practical based on BOHCT3.2**	**25**	**1**	**3**
TOTAL (Group A + B)		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: Internal Assessment (30) + Term End Examination (45)
TEE: Group A (20 points) + Group B (25 points)
PRACTICAL: Internal Assessment (10) + Term End Examination (15)

Theory (Group A)

Points: 20 **Classes/ Semester: 20**

Plant Molecular Biology

1. Protein structure and function, amino acid sequencing, protein analysis (electrophoresis, s-value crystallography, mass spectrophotometry, x-ray crystallography). **(3)**

2. Protein sorting: protein targeting in organelles. **(2)**

3. Nucleic acid: Structure, chemical and physical properties, nuclear, chloroplast and mitochondrial genome. **(4)**

4. Recombinant DNA Technology: Restriction enzymes, cloning vectors, construction of recombinant DNA. **(4)**

5. Biology of RNA types: Ribosomal RNA, transfer RNA and messenger RNA; post m-RNA modifications, RNA splicing, Regulatory RNAs and related phenomenon: si-RNA, mi-RNA, Ribozyme, antisense RNA, RNAi, Riboswitch. **(4)**

6. Blotting techniques: Southern, Northern and Western Blot; DNA fingerprinting, DNA foot printing, basic idea of proteomics and genomics, c-DNA and genomic library. **(2)**

7. Bioinformatics: Definition, importance, constituents, application in genomics. **(1)**

Theory (Group B)

Points: 25 **Classes/ Semester: 25**

Biotechnology

1. Plant tissue culture: Organogenesis, embryogenesis, haploidy & DH populations in biotechnology and crop improvement. Biochemical and molecular genetic regulation on cellular totipotency. **(2)**
2. Genetic transformation: Protoplast system (electroporation and PEG) agrobacterium system, en-planta transformation and biolistic systems; screenable and selectable markers; chloroplast transformation; marker free methodologies. **(2)**
3. Biotechnological applications for crop management: i) herbicide resistance ii) insect and pest management iii) bio- fortified crops iv) molecular firming v) bio sensors vi) phyto remediation. **(2)**
4. Secondary metabolite production in plant cultures: Types of culture systems used for secondary metabolite production; improving secondary metabolite production in culture; elicitation using biotic and abiotic elicitors; bio transformations; hairy root culture and screening and selection of high secondary metabolite producing cell lines; metabolic engineering for production of secondary metabolites. **(3)**
5. Micropropagation and commercial micro propagation: Production of virus free plants, virus free assessment methods, genetic assessment by RAPD and ISSR markers, field evaluation, certification for quality plants, packaging technology and transport methods. **(1)**
6. Fermentation technology: application of fermentation; batch, fed batch and their continuous cultures of microbes; Bioreactors: Principles and their design; microbial strain improvement. **(4)**
7. Immobilization of microbial enzymes and whole cells and their applications in industries. **(2)**
8. Microbes as food and in food processing, single cell protein. **(4)**
9. Biofertilizers and biopesticides in agriculture. **(2)**
10. Environmental biotechnology: Treatment of waste & waste water; bioremediation. **(2)**
11. Regulatory issues in biotechnology: Intellectual property rights (IPR): Patents, plant variety protections & geographical indications, WTO & TRIPPS, Bio safety and Food safety of GMO - a brief outline. **(1)**

Practical Course: BOHCP3.2 (Based on BOHCT3.2 –Plant Molecular Biology & Biotechnology)

Points: 15 **3 hours/ week**

1. Isolation & purification of plant proteins by salting out process.
2. Gel electrophoresis of protein.
3. Estimation of protein by Lowry's method.
4. Isolation and purification of DNA and RNA.
5. Estimation of DNA and RNA.
6. Isolation of chloroplast, Determination of Hill activity.
7. Isolation and purification of an enzyme.
8. Determination of K_m of enzyme.
9. Demonstration on agarose gel electrophoresis technique for DNA.

10. Plant tissue culture techniques (media preparations), culture of explants (embryo, shoot tips, nodal segments).

11. Anther culture of a dicot and monocot plants.

12. Plant transformation systems (demonstration).

13. Detection of fungal products - organic acids, alcohol & cellulose enzyme.

14. Selection of different species of *Aspergillus* for better amylase production.

15. Mushroom cultivation (demonstration).

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOHCT3.3	**Plant Ecology, Biodiversity & Conservation**	**75**	**3**	**4**
BOHCP3.3	**Practical based on BOHCT3.3**	**25**	**1**	**3**
TOTAL (Group A + B)		**100**	**4**	**7**

EVALUATION SCHEME - THEORY: **Internal Assessment (30) + Term End Examination (45)**
TEE: 45 points
PRACTICAL: **Internal Assessment (10) + Term End Examination (15)**

Theory

Points: 45 **Classes/ Semester: 45**

Plant Ecology, Biodiversity & Conservation

1. Introduction to Ecology: scope and nature of plant ecology. **(1)**
2. Approaches in ecological studies: formulating hypothesis; theoretical ecological models; probabilistic ecological models; statistical approaches; phylogenetic approaches; remote sensing; climate diagrams. **(5)**
3. Abiotic environment: variables in action; influence of abiotic environment on distribution and abundance of plants. **(2)**
4. Biotic environment: levels of organization of organisms in ecology; plant interactions. **(1)**
5. Habitat and Niche: concept of habitat and niche; niche width and overlap; fundamental and realized niche; competitive exclusion principle; extinction; resource partitioning; character displacement; speciation. **(3)**
6. Population ecology: characteristics of population; population growth curves, population regulation, life history strategies (*r* and *K* selection); metapopulations – habitat fragmentation, demes, source-sink model. **(4)**
7. Community ecology: concepts of community, assemblage and guilds; open and closed communities, ecotone; community continuum concept; community structure; measures of community structure – diversity indices, similarity measures, food web analysis; succession - types, mechanisms, concept of climax. **(5)**

8. Ecosystem ecology: concept of ecosystem, disturbance (natural and anthropogenic) and their impact on plant ecology; invasive plant species; resistance and resilience of ecosystems. **(3)**
9. Biogeographical ecology: terrestrial ecology; wetland and freshwater ecology; coastal and marine ecology; major biogeographical zones of India. **(5)**
10. Biodiversity: Concept, kinds/ levels, importance, methods of study, protection from depletion; Mega - diversity and Hotspots. **(6)**
11. Threats to Biodiversity: Causes of threats; Concepts of rare, vulnerable, endangered and threatened plants (IUCN categories). **(2)**
12. Conservation: Types of conservation - *in-situ* conservation: Biosphere Reserve, Wildlife Sanctuaries, National Parks , World Heritage Cites; Concept and types of Protected Areas Networks; *ex-situ* conservation: principles, methods, definition, aims and activities of W.W.F., Red Data Book, MAB, CITIES. Role of Botanic Gardens and Gene Banks. **(8)**

Practical Course: BOHCP3.3 (Based on BOHCT3.3 – Plant Ecology, Biodiversity & Conservation)

Points: 15 **3 hours/ week**

1. Quadrat Analysis:
   a. Determination of minimum quadrat size by species-area curve.
   b. Determination of minimum number of quadrats to be laid down.

2. Quantitative assessment of communities:
   a. Determination of frequency, density and abundance of a terrestrial herbaceous plant community, preparation of frequency diagram and comparison of the same with the Normal Frequency Diagram.
   b. (The species recorded from the field should be submitted as herbarium specimens).
   c. Study of an aquatic/ wetland plant community/ phytoplankton community for assessment of diversity by measurement of species diversity index.
   d. (The aquatic/ wetland species recorded from the field should be submitted as wet specimens).

3. Qualitative assessment of communities:
   a. Comparison of three different plant communities using different similarity coefficients.

4. Exercise in designing ecological experiments:
   a. Formulation of hypotheses/ research questions to explain any given natural phenomenon and designing an experiment based on approaches in ecology to test the same.

5. Field visit: One field excursion to any of the following ecosystems: (a) terrestrial (forest/ grassland) or (b) aquatic (freshwater/ estuarine). Only Field Note Books to be submitted.

Note: Regularly checked laboratory records, dried and wet specimens collected during field works should be submitted in a proper way at the time of term-end examination.

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SOFT CORE THEORY COURSES (Any **two** to be chosen from following Courses)

BOSCT3.1 Environmental Biology	**BOSCT3.4 Medical Mycology**
BOSCT3.2 Forensic Botany	**BOSCT3.5 Molecular Genetics**
BOSCT3.3 Industrial Microbiology	**BOSCT3.6 Seed Physiology**

Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.1	**Environmental Biology**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Environmental Biology

1. An introduction to environmental biology. **(1)**
2. The biosphere- The terrestrial biomes and the aquatic biomes. **(2)**
3. Basic ecological concepts and processes- Energy in ecosystem, food chain and food web**.** **(3)**
4. Biogeochemical cycles- Concept, gaseous and sedimentary cycle, nitrogen, sulphur and phosphorous cycles. **(3)**
5. Environmental pollution- Pollution and pollutant- Concept, definition and characteristics **(16)**
   a. Air pollution- Source and types of air pollutant and their chemistry, photochemical reactions, green house and global warming, O_3 depletion, acid rain, air pollutant in India
   b. Water pollution- Source and type of water pollution, effect of water pollution on ecosystem, heavy metals and their effect on biota, nuclear pollution and thermal pollution
   c. Electronic waste (e waste), sources and types, constituents of e waste, recycling of e waste, impact of e waste on environment and its management
   d. Soil pollution- Sources and classes of soil pollutants and their environmental effects, solid waste-pollution and disposal problems, waste- effect disposal and management
   e. Pesticides, classification, chemical pollution, effect on living organisms.
6. Environmental toxicology- Principles and mechanisms. **(3)**
7. Environmental laws and policies. **(2)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.2	**Forensic Botany**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Forensic Botany

1. Introduction: Introduction to forensic botany **(3)**
2. Collection and preservation of botanical evidences: Botanical samples, outdoor crime scene consideration **(3)**
3. Analysis of samples: Plant anatomy; pollen analysis; DNA analysis; plant DNA typing. **(9)**
4. Classic forensic botany cases: Case histories by using Plant anatomy and systematic, Palynology, Plant ecology, Limnology, Plant Molecular Biology and DNA, Drug enforcement and DNA. **(15)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.3	**Industrial Microbiology**	**50**	**2**	**2**

EVALUATION SCHEME - THEORY: **Internal Assessment (20) + Term End Examination (30)**
TEE: 30 points

Theory

Points: 30 **Classes/ Semester: 30**

Industrial Microbiology

1. Scope of Industrial Microbiology**:**
   - **a.** Definition and use of the term 'fermentation'. **(1)**
   - b. History (An Art from the Past, a Skill for the Future). **(1)**
   - **c.** Organizational set-up in an industrial microbiology establishment. **(1)**
   - **d.** Upstream processing (USP) and downstream processing (DSP). **(1)**
   - **e.** A typical bioprocess: introduction, advantages and limitations. **(1)**
   - **f.** Industrial fermentation products and their producer microorganisms. **(1)**
   - g. Patents and Intellectual Property Rights. **(2)**
2. Industrial Microorganisms:
   - **a.** Characteristics of important microbes used in Industrial Microbiology. **(1)**
   - **b.** Isolation of suitable producer microorganisms from the environment. **(1)**
   - c. Concept and examples of microorganisms classified as Generally Regarded As Safe (GRAS) **(2)**
   - **d.** Industrial producer strains and strain improvement. **(2)**
   - **e.** Use of mutants/ Genetically Modified Microorganisms (GMM) as against Wild type isolates for production. **(2)**
   - **f.** Aseptic and non-aseptic fermentations. **(1)**
   - **g.** Fermentation types according to the organization of the biological system (suspended and support culture) **(2)**
3. Fermenter: Different types of fermenter: Stirred Tank, Bubble column, Air Lift, Packed-bed etc.**(3)**
4. Industrial Production: Industrial production of (using most common and low-cost raw materials) Ethyl Alcohol, Acetic Acid, Penicillin, Vitamin B12, Amylase, Lysine, Streptomycin. **(8)**

Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.4	**Medical Mycology**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Medical Mycology

1. Mycoses of vertebrates: types, symptoms and treatment. **(6)**
2. Mycotoxicosis: impact of aflatoxins and other toxins on human health. **(6)**
3. Mycetismus and mushroom poisoning. **(6)**
4. Fungi as allergens. **(6)**
5. Fungi used for preparation of drugs and medicines. **(4)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.5	**Molecular Genetics**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Molecular Genetics

1. Molecular nature of gene: Physical chemistry of nucleic acids; DNA topoisomerase and supercoiling, DNA recombination kinetics; Cot-curve and its significance. **(2)**

2. DNA replication: Basic mechanism and enzymology; DNA polymerase; replication in prokaryotes and eukaryotes. **(3)**

3. Genetic recombination: Molecular basis of chromosome pairing; Rec BCD pathway; double strand model in yeast; gene conversion in bread mold; site specific recombination. **(3)**

4. Regulation of gene expression in eukaryotes: various motifs involved in DNA – protein interaction during transpiration, chromatin remodeling. **(2)**

5. RNA biology- different categories of small non coding RNAs, mechanism of RNA interference and gene silencing, application of RNA in crop improvement. **(3)**

6. Genomics: An overview genome sequencing strategies, genomes of Arabidopsis and human. Genome annotation, genome duplication, Approaches to analyze different gene expression, ESTs, microarray and DNA chips and their application. **(4)**

7. Proteomics: Concept proteome, application of proteomics, protein mining, protein expression profiling, protein network mapping, protein modification and analysis. **(3)**

8. Molecular mapping of genomes: Drawbacks of conventional mapping technique; tools of molecular mapping of genomes: restriction map, clone contig map, radiation hybrids, ESTs markers. **(4)**

Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT3.6	**Seed Physiology**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)**			
	TEE: 30 points			

Theory

Points: 30 **Classes/ Semester: 30**

Seed Physiology

1. Seed Formation: Self fertilization, cross fertilization; seed development - embryogeny, types of embryo development, laws of embryony, endosperm development, Overall seed development - morphological development, changes in weight, chemical changes, environmental effects. **(3)**
2. Hormones and chemical stimulants in seed germination control. **(4)**
3. Importance of cellular repair in germination and vigor. **(2)**
4. Phenomenology of seed germination: Reactivation of cellular activity during germination, timing of Gibberellin action during seed germination. **(4)**
5. Translational and post translational control of seed germination. **(4)**
6. Metabolic transitions in seed germination. **(3)**
7. Seed vigor: manipulation. **(5)**
8. Seed longevity and deterioration: Life span of seeds, concepts of seed deterioration, factors influencing life span of seeds, symptoms of causes of seed deterioration. **(5)**

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ELECTIVE PAPER: Elective Paper allotment will be made during 3rd Semester

Any **one** single combination of Course – I & Course – II from the following

Course - I	BOECT4.1	Genetics, Molecular Genetics, Biometry & Plant Breeding
Course - II	BOECT4.2	Genetics, Molecular Genetics, Biometry & Plant Breeding
Course - I	BOECT4.3	Microbiology
Course - II	BOECT4.4	Microbiology
Course - I	BOECT4.5	Mycology & Plant Pathology
Course - II	BOECT4.6	Mycology & Plant Pathology
Course - I	BOECT4.7	Phycology
Course - II	BOECT4.8	Phycology
Course - I	BOECT4.9	Plant Physiology, Plant Biochemistry & Plant Molecular Biology
Course - II	BOECT4.10	Plant Physiology, Plant Biochemistry & Plant Molecular Biology
Course - I	BOECT4.11	Pteridology & Palaeobotany
Course - II	BOECT4.12	Pteridology & Palaeobotany
Course - I	BOECT4.13	Taxonomy of Angiosperms & Biosystematics
Course - II	BOECT4.14	Taxonomy of Angiosperms & Biosystematics

SEMESTER – 4

Course	Subject	Points	Credits	Hrs./Wk.
BOET4.1	Genetics, Molecular Genetics, Biometry & Plant Breeding (Course - I)	**100**	**4**	**6**
BOET4.2	Genetics, Molecular Genetics, Biometry & Plant Breeding (Course - II)	**100**	**4**	**6**
BOEP4.1	Practical based on BOET4.1 & BOET4.2	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.1 + BOET4.2 + BOEP4.1 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME:	**THEORY (BOET4.1):**	**Internal Assessment (40 points) + Term End Examination (60 points)**
	THEORY (BOET4.2):	**Internal Assessment (40 points) + Term End Examination (60 points)**
	PRACTICAL:	**Internal Assessment (30) + Term End Examination (45)**

Theory (Genetics & Molecular Genetics)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Genetic Engineering and genomics: Restriction enzymes; cloning vectors (plasmids, cosmid, phagmids, YAC, BAC); cloning strategies, polymerase chain reaction sequencing strategies, DNA gel electrophoresis; blotting techniques; c-DNA library, DNA foot printing, DNA finger printing. **(8)**

2. Transgenics: Development strategies. Trangenics in relation to insect, herbicide, stress resistance; delayed fruit ripening; golden rice; vaccine development; male sterility; molecular farming; flower colour; terminator gene sequence. **(12)**

3. Genetic diseases. Pedigree analysis. Gene therapy and genetic counselling. **(4)**

4. Gene knockout mutation in reference to mice and yeast models. **(3)**

5. Gene regulation at the level of transcription and translation in eukaryotes. **(8)**

6. Meiotic configurations in plant species: asynapsis, desynapsis, reciprocal translocation, inversion, F_1 hybrid and amphidiploids. **(4)**

7. Dosage compensation. **(3)**

8. RNA editing and evolutionary significance; antisense RNA technology and gene silencing. Ribozyme. **(2)**

9. Cancer: Properties of cancer cells. Transfection test. Genetic basis of cancer. Characterization of p^{53} and its role in regulation of cancer. Role of gene mutation, reciprocal translocation, insertion of retroviral genome and constitutive amplification in cancer development; environmental carcinogenesis; therapy and side effects. **(8)**

10. Blood group genetics in ABO system. **(3)**

11. T-DNA technology: T-DNA transfer, disarming of T-DNA, cointegrates; direct and indirect methods of gene transfer. Binary vector. Shuttle vector. **(4)**

12. Genomics: Structural genomics, molecular markers and mapping of genome using - RFLP, RAPD, AFLP and micro-satellite marker; chromosome walking; Functional genomics: DNA microarray and chip technology; a brief idea on Human Genome Project. **(6)**

13. Polyploidy in angiosperms - genetic insight to the phenomenon. **(3)**

Theory (Plant Breeding & Biometry)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Male Sterility: Induction, characterization and application. **(6)**
2. Self incompatibility: Types, significance; procedure for overcoming self incompatibility. **(4)**
3. Distant hybridization: Barriers and achievements. Bridge species. **(5)**
4. Back cross method of breeding: Significance and limitations; multiline concept. **(5)**
5. Molecular marker assisted breeding. Molecular markers in genome and QTL analyses. **(3)**
6. Breeding and biotechnological approaches for nutritional quality in crop plants (Maize and Legumes). **(5)**
7. Breeding and biotechnological approaches for resistance to abiotic stress (salinity, drought and cold). **(6)**
8. Breeding and biotechnological approaches in oil yielding crops (Soybean). **(6)**
9. Genetics of disease resistance in crop plants. **(5)**
10. Concept of heritability. **(2)**
11. Use of biometrical tests (χ^2 test, T-test, correlation and regression analysis, path analysis, ANOVA) in breeding and genetical experiments. **(25)**

Practical Course: BOEP4.1 (Based on BOET4.1 & BOET4.2 - Genetics, Molecular Genetics, Biometry & Plant Breeding)

Points: 45 **8 hours/ week**

1. Comparative study of karyotypes of selected plant materials (both from root tips and leaf tips).
2. Scanning of chromosome aberrations (mitotic and meiotic).
3. Chromosomes - Nucleolus relationship, nucleolar staining.
4. Demonstration of alkaline phosphate activity on plant chromosome.
5. Localization of DNA *in situ*.
6. Extraction, identification and estimation of macromolecules DNA, RNA and protein.
7. Gel electrophoresis study of DNA and protein.
8. Amplification of extracted DNA from plant material.
9. Micropropagation and induction of embryogenesis (somatic and gametic).
10. Cell suspension culture technique and induction of organogenesis and embryogenesis.
11. Effect mutagenic agent on plant system to note chromosomal irregularities.
12. Isolation and analysis of secondary metabolite in vitro.
13. Study of chromosomes from tissue culture generated plants
14. Data analysis using biometrical methods.
15. Determination of T_m value and cot-value.

Note: Regularly checked laboratory records should be submitted at the time of term-end examination.

Course	Subject	Points	Credits	Hrs./Wk.
BOET4.3	Microbiology (Course - I)	**100**	**4**	**6**
BOET4.4	Microbiology (Course - II)	**100**	**4**	**6**
BOEP4.2	Practical based on BOET4.3 & BOET4.4	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.3 + BOET4.4 + BOEP4.2 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME: **THEORY (BOET4.3):** **Internal Assessment (40 points) + Term End Examination (60 points)**
THEORY (BOET4.4): **Internal Assessment (40 points) + Term End Examination (60 points)**
PRACTICAL: **Internal Assessment (30) + Term End Examination (45)**

Theory (Microbiology)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Environmental Microbiology

a) Microbes in the environment and its significance. Microbial evolution & diversity in nature. **(5)**

b) Interaction among populations: plant-microbes; animal-microbes and microbe-microbe interaction, biofilm and its significance. **(6)**

c) Distribution of microbes in natural habitats and ecological factors involved there in:

i) Atmospheric microbiology- quantitative ecology of air microbes, Microbial air pollution. **(3)**

ii) Water microbiology - assessment of water quality, microbes as bio-indicators of water purity, water purification. **(3)**

iii) Waste water treatment, sludge treatment. **(4)**

iv) Quantitative estimation of the population dynamics of soil microorganisms. **(3)**

d) Role of microbes in mineral recovery, microbial leaching of metals. **(3)**

e) Biogeochemical cycles and microbes: Carbon cycle, nitrogen cycle, phosphorus cycle, sulphur cycle. **(3)**

f) Microbes and ecological managements - Bioremediation, general features of biodegradation of xenobiotics, biodegradations of halocarbons, synthetic polymers, lignin, oil mixture. **(5)**

2. Agricultural microbiology: Exploitation of microbes for crop improvement and crop protection, biological control of plant diseases, biopesticides (bioinsecticides), biofertilizers. **(7)**

3. Medical microbiology**:** Principles of epidemiology, air borne transmission, sexually transmitted diseases, arthropod transmitted diseases, soil borne diseases, food and water borne diseases, disease cycle (Two examples of each type prevalent in India and world and their biology, pathology, therapy and prevention). **(18)**

Theory (Microbiology)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Microbial Genetics

a. Genomic structure and organization of viruses and bacteria. **(2)**

b. Bacterial genome replication and cell cycle. Plasmid replication and its maintenance; Prokaryotic transcription and translation. **(6)**

c. Regulation of gene expression in prokaryotes. **(2)**

d. Genetic recombination – transformation, conjugation and transduction. **(6)**

e. RNA world, Evolution of bacterial species- 16S rRNA based Phylogeny. **(4)**

f. Viral replication, molecular basis of regulation of lytic and lysogeny cycle, viral induction, oncogenic virus. **(6)**

2. Industrial microbiology

a. Genetic engineering for the development of strains. **(2)**

b. Different types of bioreacters: Stirred Tank, Bubble column, Air Lift, Packed-bed. **(3)**

c. Industrial production of Ethyl Alcohol, Acetic Acid, Penicillin, Vitamin B12, Amylase, Lysine, Streptomycin. **(7)**

3. Immunology

a. Overview of the Immune system. **(1)**

b. Innate immunity and adaptive immunity, major histocompatibility complex (MHC) and their role in antigen presentation, cytokines. **(3)**

c. Antigen - chemical nature, antigenicity, immunogenicity, hapten, epitopes, mitogens definition, properties, examples); adjuvant (definition, examples, function). **(3)**

d. Monoclonal and polyclonal antibody (definition, characteristics and production). **(3)**

e. Agglutination, precipitation, immunodiffusion, immunoelectrophoresis. **(3)**

f. Hypersensitivity: definition, types, examples. **(2)**

g. Active & passive immunization (definition, characteristics, examples & functions). Attenuated & inactivated viral or bacterial vaccines (definition, characteristic, functions, examples). **(3)**

h. ELISA, RIA, Immunofluorescence, Flow cytometry, Fluorescence Activated Cell Sorting (FACS). **(4)**

Practical Course: BOEP4.2 (Based on BOET4.3 & BOET4.4 - Microbiology)

Points: 45 **8 hours/ week**

1. Isolation and characterization of bacteria from different habitat.

2. Growth study of *Escherichia coli/ Staphylococcus aureus* in presence of various inhibitors/ stimulators in the medium.

3. Determination of potability of water - MPN method.

4. Isolation of root nodule bacteria, their characterization and induction for root hair curling and artificial nodulation.

5. Isolation of phosphate solubilizing, cellulose degrading, nitrogen fixing, IAA producing bacteria from soil.

6. Determination of phenol coefficient of different common disinfectants.

7. Microbial quality assessment of salad vegetables.

8. Determination of MIC of different chemicals for inhibition of bacterial growth.

9. Isolation and identification of *Escherichia coli*, fecal *E. coli* and *Salmonella* from domestic water and scoring of antibiotic resistant cells present in the population.

10. Isolation of bacterial DNA and its quantification by chemical method.

11. Induced mutagenesis and selection of mutants; replica plating technique.

12. Detection of soil protozoa having predatory role on soil bacteria.

13. Visit to any industry/ research institute and reporting the activity.

Note: Regularly checked laboratory records and specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOET4.5	Mycology and Plant Pathology (Course - I)	**100**	**4**	**6**
BOET4.6	Mycology and Plant Pathology (Course - II)	**100**	**4**	**6**
BOEP4.3	Practical based on BOET4.5 & BOET4.6	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.5 + BOET4.6 + BOEP4.3 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME: **THEORY (BOET4.5):** **Internal Assessment (40 points) + Term End Examination (60 points)**
THEORY (BOET4.6): **Internal Assessment (40 points) + Term End Examination (60 points)**
PRACTICAL: **Internal Assessment (30) + Term End Examination (45)**

Theory (Mycology and Plant Pathology)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Origin of fungi and their interrelationships; phylogeny, affinities and position of fungi in modern systematic. **(6)**

2. Fungal metabolism - chitin synthesis, lysine biosynthesis, pathway and precursors of secondary metabolism (polyketide pathway, isoprenoid pathway, shikimic acid pathway). **(5)**

3. Genetic variation in fungi: sexual and non-sexual variation and their significance; detection of genetic variation in populations. **(10)**

4. Genomics for fungi: characterization, cloning and expression of heterologous genes in industrially important filamentous fungi. **(8)**

5. Differentiation and sex hormones in fungi: morphogenesis in slime molds, mould-yeast dimorphism, mating and hormonal control. **(8)**

6. Regulation of protein synthesis in fungi; heat shock protein and chaperon, development of thermo-tolerance by heat-shock and other stresses. **(8)**

7. Role of saprotrophs in ecosystems; deterioration and decay of wood; mycoremediation. **(6)**

8. Industrial production of citric acid, alcohol, enzymes and antibiotics. **(5)**

9. Culture repositories and methods of preservation of fungal cultures; Mycological databases; GenBank repositories, open source computational and other internet resources for Mycologists and Plant Pathologists; searching and retrieving from databases. **(4)**

Theory (Mycology and Plant Pathology)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Molecular basis of plant-pathogen interaction: phenomenon of infection, recognition. **(8)**

2. Pathogenesis: mode of action and role of toxins, role of enzymes and growth regulators. **(8)**

3. Molecular aspect of plant disease resistance: role of phenolics, phytoalexins, phytoanticipins, pathogenesis related proteins (classes & functions in plant disease resistance), other antifungal proteins, reactive oxygen species & lipoxygenase; hypersensitive reactions: mechanism of elicitor -receptor concept; systemin; systemic acquired resistance, induced systemic resistance. **(15)**

4. Fungal evasion of host defense. **(2)**

5. Genetics of pathogenecity: major and minor gene resistance, genetics of resistance and susceptibility, genes for virulence and avirulence. **(5)**

6. Epidemiology of plant diseases; disease pyramid: components, measurement and simulation of plant disease epidemics; forecasting and remote sensing. **(4)**

7. Plant disease diagnosis utilizing molecular tools. **(2)**

8. Development of disease resistant variety by mutation, breeding and recombinant DNA technology; RNAi in plant pathology. **(4)**

9. Biological control: current status, constrains and future prospect. **(4)**

10. Systemic fungicides: their application and mode of action; mechanisms of fungicide resistance; antibiotics used in plant disease control. **(6)**

11. Brief account of seed pathology and post harvest diseases and their control. **(2)**

Practical Course: BOEP4.3 (Based on BOET4.5 & BOET4.6 – Mycology and Plant Pathology)

Points: 45 **8 hours/ week**

1. Determination of carbohydrate, protein and phenol contents of healthy and diseased tissues
2. Study of factors affecting cell wall degrading enzyme activity- pH and temperature
3. Isolation of fungi from soil and water samples
4. Preparation of monosporous-, polysporous- and tissue- culture
5. Study of hyphal types and hyphal system
6. Study of fungal nuclei
7. Isolation of fungal/plant DNA and its quantification by spectrophotometric method; separation of DNA by agarose gel electrophoresis; amplification of genomic fragment by polymerase chain reaction
8. Induction and bioassay of phytoalexin in host plants

9. Extraction and SDS-PAGE analysis of defense protein in artificially inoculated plants/ induced by abiotic elicitor(s)
10. Assay of fungicide by spore germination test
11. Biological control by dual culture technique
12. Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOET4.7	Phycology (Course - I)	**100**	**4**	**6**
BOET4.8	Phycology (Course - II)	**100**	**4**	**6**
BOEP4.4	Practical based on BOET4.7 & BOET4.8	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.7 + BOET4.8 + BOEP4.4 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME:
THEORY (BOET4.7): Internal Assessment (40 points) + Term End Examination (60 points)
THEORY (BOET4.8): Internal Assessment (40 points) + Term End Examination (60 points)
PRACTICAL: Internal Assessment (30) + Term End Examination (45)

Theory (Phycology)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Morphology and ultrastructure of the prokaryotic and eukaryotic algal cell: Structural organization and functions of - cell wall, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, plastids, vacuoles and chloroplast. **(5)**

2. Evolution and Phylogeny of algal groups: Endosymbiotic theory; Fan-shaped phylogenetic tree; Molecular phylogenetic approaches; Position of algae in the classification system; Evolution of the algal chloroplast. **(5)**

3. Evolutionary trends and phylogeny of the following algal groups: Prochlorophyta, Glaucophyta, Euglenophyta, Cryptophyta, Heterokontophyta (Chrysophyceae and Eustigmatophyceae); Concepts of Streptophyta; Apicomplexa; Chlorarachniophyta; Chromista. **(15)**

4. Cyanobacteria: Molecular approach to taxonomy and species concept. **(5)**

5. Algal genetics: General features of algal genomes; Classical and modern concepts in algal systematics; *Chlamydomonas*: as a model genetic system; *Acetabularia*: for studying gene expression and morphogenesis; Horizontal gene transfer in prokaryotes and eukaryotes. **(8)**

6. Algal photosynthesis: Light-acquisition, photoprotection, photoinhibition, carbon fixation; Light harvesting pigments – Chlorophylls, Carotenoids and Phycobiliproteins; Chromatic adaptation; Pigment diversity and chemotaxonomy. **(12)**

7. Algal response to stress: Salinity, desiccation, temperature, light intensity, UV-B radiation; Production and application of stress products. **(5)**

8. Fossil algae: Major events in the geological time scale during evolution of algae in relation to corresponding environment and other life forms; Fossil history of the algal groups Cyanobacteria, Rhodophyta, Chlorophyta, Dinophyta and Bacillariophyceae. **(5)**

Theory (Phycology)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Algal Culture: Axenic culture, Batch, continuous and semi-continuous culture; Outdoor mass culture of microalgae; Photobioreactors; Immobilized algal cells; Culture collections and preservation of algal strains. **(5)**

2. Algal Pigments: Production and application of algal biocolorants - Phycocyanin, Phycoerythrin, allophycocyanin, Astaxanthin, & beta-carotene along with their commercial potentials. **(10)**

3. Biogeochemical role: Limiting nutrients; Algae in - carbon cycle, nitrogen cycle, sulfur cycle and silicon cycle; Production of halocarbon compounds. **(4)**

4. Biotechnological applications: Secondary metabolites of algae; Use of algae as source of pharmaceutical and cosmetic products; Production and application of algal hydrocolloids (agar, alginates, carrageenan); Biodiesel and hydrogen production by algae; Algal techniques for restoration/ maintenance of soil fertility; Algal biofertilizers (BGA biofertilizer and seaweed liquid biofertilizer); Use of algae in nanotechnology. **(15)**

5. Biotic associations: in food webs, as parasites or pathogens, as epibionts and in mutualistic symbiosis. **(4)**

6. Phytoplankton ecology: Characteristics of the physical environment; Characteristics of the chemical environment; Growth processes; Loss processes; Nutrient uptake models (Michelis-Menten, Monod & Droop); Competition, spatial heterogeneity, disturbance and coexistence; r and k strategists; Trophic cascades and bio-manipulation. **(12)**

7. Algal Ecology: macroalgae, periphyton, marine and turf forming algae and terrestrial algae. **(4)**

8. Algal pollution: Freshwater and marine pollution; monitoring of pollutants; strategies for controlling eutrophication; phycoremediation. **(4)**

9. Seaweeds and their uses: Historical perspectives and linkages with modern economy and food security. **(2)**

Practical Course: BOEP4.4 (Based on BOET4.7 & BOET4.8 – Phycology)

Points: 45 **8 hours/ week**

1. Work out of algae samples belonging to major algal groups for identification up to species level and comparative accounts of sets of two samples at generic and species levels.

2. Collection and work out of

(a) Phytoplankton

(b) Periphyton
(c) Epipelon
(d) Epilithon

3. Limnological studies in different water bodies:

(a) Qualitative and Quantitative estimation of phytoplankton for use as biological assessment of water quality.

(b) Estimation of DO, BOD, Salinity, Alkalinity, Nitrate and Phosphate for chemical assessment of water quality.

4. Algae immobilization exercise - preparation of algal beads.

5. Extraction and estimation of various algal pigments: chlorophyll, carotenoid and phycocyanin.

6. Algal cytology study.

7. General principles of culturing algae in the laboratory and growth measurements.

8. Field visits for collection of estuarine/ marine/stream algae, their preservation and enumeration.

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, dry and wet specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOET4.9	Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course - I)	**100**	**4**	**6**
BOET4.10	Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course - II)	**100**	**4**	**6**
BOEP4.5	Practical based on BOET4.9 & BOET4.10	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.9 + BOET4.10 + BOEP4.5 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME:
THEORY (BOET4.9): Internal Assessment (40 points) + Term End Examination (60 points)
THEORY (BOET4.10): Internal Assessment (40 points) + Term End Examination (60 points)
PRACTICAL: Internal Assessment (30) + Term End Examination (45)

Theory (Plant Physiology, Biochemistry & Plant Molecular Biology)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Biogenesis of plant products: Biosynthesis of purines & pyrimidines & their nucleotides, ascorbic acid, flavonoids, carotenoids, terpenes and terpenoids, rubber, plant sterol, chlorophylls. **(10)**

2. Ca^{2+} signalling in higher plants. **(4)**

3. Cytokinin signalling network. **(4)**

4. Protein transport in the chloroplast. **(3)**

5. Photosystem I- function and physiology. **(4)**

6. One carbon metabolism in higher plants. **(4)**

7. Organisation and regulation of mitochondrial respiration in plants. **(4)**

8. ABA- emergence of core signalling system in plants. **(4)**

9. Alteration of gene expression in higher plants due to environmental stress. **(4)**

10. Assimilation of sulphur, phosphate, cation and oxygen. The energetics of nutrient uptake. **(4)**

11. Immunoassay of plant growth regulators. **(5)**

12. Rapid gene action by auxin. **(5)**

13. Amino acid metabolism- Oxidation of amino acids, biosynthesis, of protein amino acids. **(5)**

Theory (Plant Physiology, Biochemistry & Plant Molecular Biology)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Methods of extraction and purification of plant products: adsorption, partition and ion exchange chromatography, HPLC, gel filtration, gas chromatography, electrophoresis and density gradient centrifugation, and ultracentrifugation. **(18)**

2. Methods of characterization of compounds: visible, infra red and UV spectroscopy, mass spectroscopy, nuclear magnetic resonance, Fluorescence and Raman effects, X-ray diffractions, turbidometry, flame photometry, Lambert - Beer's law, principle and applications of tracer techniques in biology. **(18)**

3. Molecular biology of higher plants:

a) Molecular genetics of gibberellins in higher plants. **(3)**

b) Molecular analysis of photosystem II- structure and function. **(3)**

c) Molecular biology of fruit ripening and maturation. **(3)**

d) Photorespiration and C_4 photosynthesis. **(3)**

e) Molecular mechanism of flowering, gene expression during flower development, chemical induction and control of flowering. **(3)**

f) Gene dissection of RUBISCO, structure and function. **(3)**

g) Seed germination and vigor in plants. **(3)**

Practical Course: BOEP4.5 (Based on BOET4.9 & BOET4.10 – Plant Physiology, Plant Biochemistry & Plant Molecular Biology)

Points: 45 **8 hours/ week**

1. Quantitative estimation of nitrogen by Kjeldahl's method.

2. Determination of succinic dehydrogenase in plant tissue.

3. Determination of ascorbic acid oxidase activity in plant tissue.

4. Paper and thin layer chromatography of amino acids and sugars.

5. Quantitative estimation of total soluble sugar by Anthrone method.

6. Estimation of phosphorus content by Fiske – Subbaraos' method.

7. Estimation of ascorbic acid in a plant tissue.

8. Separation of plant pigments by column chromatography.

9. Bioassay of auxin, gibberellins and cytokinins.

10. Quantitative estimation of amino acids and proteins by colorimetric method.

11. Isolation and estimation of DNA by diphenylamine reaction.

12. Isolation and estimation of RNA by weevil reaction.

13. Evaluation of T_m of DNA.

14. Gel electrophoretic study of plant protein.

Note: Regularly checked laboratory records, should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOET4.11	Pteridology & Palaeobotany (Course - I)	**100**	**4**	**6**
BOET4.12	Pteridology & Palaeobotany (Course - II)	**100**	**4**	**6**
BOEP4.6	Practical based on BOET4.11 & BOET4.12	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.11 + BOET4.12 + BOEP4.6 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME: **THEORY (BOET4.11):** **Internal Assessment (40 points) + Term End Examination (60 points)**
THEORY (BOET4.12): **Internal Assessment (40 points) + Term End Examination (60 points)**
PRACTICAL: **Internal Assessment (30) + Term End Examination (45)**

Theory (Pteridology & Palaeobotany)

Points: 60 **Classes/ Semester: 60**

Course - I

1. Essentials of geology in relation to palaeobotany: Earth's interior and crust, types of rocks and their interrelationships, tectonic features - dip and strike, fold and fault, fossiliferous rocks. **(4)**

2. Continental drift, plate tectonics and plant fossils: Continental drift, plate tectonics and break up history of major continents, plant fossil evidences for the long journey of the continents. **(4)**

3. Elements of stratigraphy and time scale: Stratigraphic units, time scale, major fossil groups used in time scale, facies. **(5)**

4. Precambrian life: Origin of life on earth, Palaeo-Meso-Neo Archean life, oxygenation of earth, Palaeo-Meso-Neo Proterozoic life, stromatolites, Indian records. **(6)**

5. Palaeofloristics and phytogeography: History of floras, rise of land vegetation, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Coenozoic floras, major phytochoria. **(15)**

6. Plant fossils as palaeoenvironmental proxies & climate change event: Analysis of palaeoenvironment by using plant fossil through different methods - leaf physiognomy, NLR of coexistence model, CLAMP, stomatal density and index, dendrochronology; role of plant fossils in predicting future climate change. **(4)**

7. Microfossils, nannofossils and their implications: Morphology and significance of BGA, bacteria, dinoflagellates, acritarchs, silicoflagellates, diatoms, coccolithophores, green algae, red algae, spores and pollen grains, radiolaria, forminifera, ostracodes, chitinozoa, conodont and nannofossils. **(8)**

8. Plant-animal interactions in geologic past and their co-evolution: Early terrestrial ecosystem association, herbivory, fossil evidences, interaction with vertebrates, plants as habitat, other plant-animal interactions. **(3)**

9. Concept, limit and extension of the Indian Gondwana: Concepts of Gondwana Supergroup, Indian Gondwana plate margins and their evolutionary history, origin, rise and decline of Glossopteris flora with climatic inferences. **(4)**

10. Indian fossil flora and corresponding climate: Mesozoic flora, Palaeogene flora, Neogene flora of peninsular and extra-peninsular (Siwalik flora) India, and Deccan-Intertrappean flora, Quaternary flora of Bengal Basin in understanding climate changes, eustatic sea level change, and coastal evolution. **(12)**

11. Nature's Green Revolution: Evolutionary rise of C4 and CAM plants, the first grasses. **(2)**

12. Life as Fuel Maker: Plant fossil evidences: Palynofacies in hydrocarbon potential- peat, lignite, coal, coalification process, coal resources in the Indian Gondwana, organic origin, migration and concentration of petroleum, petroliferous basins of India. **(3)**

13. Recent perspectives in palaeobotanical research: Exploitation of ancient DNA in evolutionary research, techniques and limitations; uses of other fossil plant biomolecules, chemical constituents and stable carbon iIsotopes in palaeobotanical research. **(2)**

Theory (Pteridology & Palaeobotany)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Introduction: Concept of Pteridophyta as a single taxonomic unit and its origin. **(2)**

2. Taxonomic Treatments: Characters of some major groups of fern-families and fern-allies; phylogenetic position of Psilotales; recent taxonomic treatments of extant Lycopodiaceae and Ophioglossaceae; systematics and phylogeny of the Filicales; trends of evolutionary specialization in early land vascular plants. **(5)**

3. Ecology and Distribution: Ecological diversity of pteridophytes; Brief account of Palaeozoic and Mesozoic Lycopsids, Sphenopsids and Filicopsids in India; modern pteridophytic flora of India with special reference to endangered taxa and their conservation. **(8)**

4. Contribution of the ferns to an understanding of the life cycles of vascular plants: Sporogenesis and apospory in homosporous archegoniates, apogamy, apospory and apomixes, agamospory; relationship between heterospory and anisospory, sexuality in gametophytic growth, apogamous cycle, free sporing heterospory, the determination of femaleness in free sporing heterosporous plants. **(7)**

5. Comparative Anatomy: Stem, Root, and Leaf; types of stomata and their ontogenetic interrelationships; variation in the vasculature of petiole and the rachis and their probable lines of evolution. **(9)**

6. Cytogenetics & Genetics: Chromosome number and morphology, polyploidy and its origin in ferns; geographical distribution of polyploids; hybridization, evolutionary process in extant ferns; karyology in Psilotaceae, Isoetaceae, Lycopodiaceae, Selaginellaceae, Equisetaceae and selected ferns; breeding behavior in ferns. **(8)**

7. Spores: Structure, ontogeny and developmental trends in spores of extant pteridophytes; basic spore characters of extant pteridophytes (Psilotaceae, Lycopodiaceae, Selaginellaceae, Isoetaceae, Equisetaceae, Ophioglossaceae, Marattiaceae, Osmundaceae, Cyatheaceae, Pteridaceae, Parkeriaceae, Dennstaedtiaceae, Hymenophyllaceae, Thelypteridaceae, Polypodiaceae, Masileaceae, Salviniaceae); type species of selected spore genera of extinct pteridophytes; function of spores- predation, metabolism, germination. **(8)**

8. Gemetophyte: Effect of environment (light, temperature and different chemicals) on spore germination and early development of gametophytes; ontogeny of fern gametophytes, ultrastructure of fern gametophytic cells-protonemal cells and rhizoids, evolutionary trends in gametophyte morphology; a brief account of ultrastructural features, of male and female gametogenesis in ferns; fertilization and fertility. **(15)**

9. Chemosystematic overview: Analysis of the distribution of flavonoids, terpenoids, additional compound classes. **(2)**

10. Experimental aspects in respect to ecology: Ecology and geographic range, spore production, dispersal and viability, tolerance of desiccating conditions, deposition & establishment, prothallial development, ecological aspects of sexual maturity; various types of biotic interaction. **(8)**

Practical Course: BOEP4.6 (Based on BOET4.11 & BOET4.12 – Pteridology & Palaeobotany)

Points: 45 **8 hours/ week**

1. Geological and geographical mapping of different sedimentary basins, coal and petroliferous basins in India.

2. Study of different rock types, fold, fault, BIF, verve sediments.

3. Demonstration on the preparation of anatomical slides of fossil materials by peel techniques.

4. Study of Precambrian microbiota, stromatolite.

5. Study of external and internal morphology of fossil pteridophytes, gymnosperms and angiosperms (available specimens) through geological ages.

6. Extraction of palynofossils from coal, lignite, peat using suitable techniques and interpretation of data for reconstruction of palaeovegetation and depositional environment.

7. Study of fossil dinoflagellates and other microfossils.

8. Study of extant pteridophytic spores (at least 10 different types) by acetolysis method.

9. Comparative study of vegetative organs of pteridophytes.

10. Comparative study of reproductive structures of pteridophytes.

11. Demonstration on fern gametophytic culture under laboratory conditions.

12. Visit to Palaeobotany Gallery of Indian Museum/ University Laboratory.

13. Field tour for study and collection of fossil materials / extant pteridophytes

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.

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Course	Subject	Points	Credits	Hrs./Wk.
BOET4.13	Taxonomy of Angiosperms & Biosystematics (Course - I)	**100**	**4**	**6**
BOET4.14	Taxonomy of Angiosperms & Biosystematics (Course - II)	**100**	**4**	**6**
BOEP4.7	Practical based on BOET4.11 & BOET4.12	**75**	**3**	**8**
BOEPW4.1	Project/ Review	**25**	**1**	**4**
TOTAL (BOET4.13 + BOET4.14 + BOEP4.7 + BOEPW4.1)		**300**	**12**	**24**

EVALUATION SCHEME:
THEORY (BOET4.13): Internal Assessment (40 points) + Term End Examination (60 points)
THEORY (BOET4.14): Internal Assessment (40 points) + Term End Examination (60 points)
PRACTICAL: Internal Assessment (30) + Term End Examination (45)

Theory (Taxonomy of Angiosperms & Biosystematics)

Points: 60 **Classes/ Semester: 60**

Course - I

1. History of taxonomic study in India including the contributions by W. Roxbugh, N. Wallich, J. D. Hooker, G. King, T. Cooke, J. S. Gamble, D. Prain, J. F. Duthie, K. P. Biswas, H. Santapau, and S. K. Mukherjee. **(9)**

2. A general survey of the following taxa of angiosperms (*sensu* APG III, 2009) with special reference to their characteristics, interrelationships, evolutionary trends: Piperales, Nymphaeales, Caryophyllales, Asterales, Liliales and Orchidales. **(15)**

3. General account of parasitic and carnivores plants. **(5)**

4. ICBN: Application of code with problems; nomenclature of cultivated and hybrid plants. Rules concerning to describe a new taxon. **(5)**

5. Origin of angiosperms: Theories, evidences, place and time of origin. **(4)**

6. Floristic regions of the world (after Takhtajan 1997): Idea about different Kingdoms and Sub kingdoms. Floristic features of the following regions: Eastern Asiatic region; Madagascar region; Indo - Malaysian sub - kingdom, Polynesian sub-kingdom, Neo - Caledonian sub - kingdom, Cape Kingdom. **(6)**

7. General account of cosmopolitan families, tropical families, temperate families and discontinuous families. **(4)**

8. Migration and dispersal of plants. **(4)**

9. Diversity of Flora in India: Composition, floristic divisions (after Balakrishnan, 1996) and the characteristics flora of Eastern Himalaya, Western Himalaya and Sunderbans. **(6)**

10. Endemism in India; invasion and introduction of plants in Indian flora. **(6)**

11. Botanical Survey of India: Activities and structural organization including different circles. **(4)**

12. Taxonomic literatures: Familiarizations with classical literatures, general index, monographs and revisions, floras and manuals, glossaries and dictionaries, icons, abstract, bibliography and review. Important periodicals of India and abroad. **(4)**

Theory (Taxonomy of Angiosperms & Biosystematics)

Points: 60 **Classes/ Semester: 60**

Course - II

1. Biosystematics: Definition, aims, steps, categories, methods, limitations and scope. **(5)**

2. Variation and Speciation: Types of variation, variance analysis, isolating mechanisms and speciation. A preliminary idea about taxonomic and biological species concept and their advantages. **(6)**

3. Data sources of taxonomy: Anatomy, palynology, cytology, chemotaxonomy, serology, ultrastructure, SEM, TEM and molecular biology. **(15)**

4. Biodiversity: Concept, importance, conservation in relation to Indian perspective. Mega diversity, Hotspots. **(6)**

5. Conservation of plants: Causes of threat, IUCN - categories of rare, vulnerable, endangered and threatened plants; procedure of conservation - *in-situ* conservation: Biosphere Reserve, Wild life Sanctuaries, National Parks , World Heritage Cites; activities of Protected Area Networks; *ex-situ* conservation - principles, methods, definition, aims and activities of W.W.F., Red Data Book, MAB, CITES, Genetic resources centre: international networks, national institutions, genetic stock collection. DNA bank as Germplasm Collection. **(14)**

6. Cladistic approaches of classification: Definition; methodology of cladistics; merits and demerits of cladistics. **(5)**

7. Remote Sensing: Definition, basic principles, GIS (Geographical Information System) and GPS, applications in Botany. **(5)**

8. Ethnobotany: Definition, purpose, current trends, as a multidisciplinary science. **(6)**

9. Bio-piracy of medicinal plants of India and recommendations for promotion of traditional medicine and ethnobiology in India. Concept of ITK (Indigenous Technological Knowledge), IPR (Intellectual Property Right) and Patenting. **(8)**

10. Scope of medicinal plants for the welfare of rural people in West Bengal. **(2)**

Practical Course: BOEP4.7 (Based on BOET4.13 & BOET4.14 – Taxonomy of Angiosperms & Biosystematics)

Points: 45 **8 hours/ week**

1. Drawing and description and identification of plant specimens (fresh and dry) from selected groups or families.
2. Identification of unknown plants with the help of keys from local, regional, continental floras and manuals.
3. Preparation of artificial indented/bracketed keys at family, generic and species level, based on locally available plants.
4. Preparation of floral diagrams of some species of selected families: Acanthaceae, Scrophulariaceae, Verbenaceae, Solanaceae, Amaranthaceae, Ephorbiaceae, Bignoniaceae, Pedaliaceae, Moringaceae, Gramineae, Cyperaceae, Violaceae, Polygalaceae, Aizoaceae, Molluginaceae and Rubiaceae.
5. Solving of nomenclatural problems based on the rules of ICBN.
6. Preparation of check list of the species of a genus following the Website of www.**ipni**.org/**ipni**/query_**ipni**.html; www.**ipni**.org; http://www.britannica.com/EBchecked/topic/285218/Index-Kewensis; and the recently published local floras and periodicals.
7. Familiarity with taxonomic literatures: Dictionaries, Glossaries, Manuals, Floras, Bibliographies.
8. Study of pollen grains sculpture and aperture by revised or modified acetolysis method.
9. At least two field trips within and around the campus; compilation of field notes and preparation of herbarium sheets of the plants at least 30 abundant wild or cultivated plants.

Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.

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SOFT CORE THEORY COURSES (Any **two** to be chosen from following Courses)

BOSCT4.1 Evolution	**BOSCT4.4 Mycorrhiza and Mushroom Cultivation**
BOSCT4.2 Immunology	**BOSCT4.5 Stress Physiology**
BOSCT4.3 Intellectual Property Rights	

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT4.1	**Evolution**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Evolution

1. Emergence of evolutionary thoughts: Lamarck; Darwin – concepts of variation, Neo-Darwinism, adaptation, struggle, fitness and natural selection. **(8)**
2. Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. **(8)**
3. Evolutionary timescale & diversification of plant life: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants. **(4)**
4. Genetic variations: Origin of genetic variation; Mendelian genetics; polygenic traits, linkage and recombination; epistasis, gene - environment interaction; heritability; population genetics; molecular evolution; molecular clocks. **(10)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT4.2	**Immunology**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Immunology

1. Introduction: overview of the immune system. **(1)**
2. Cells and organs of Immune system: Hematopoietic stem cells, stromal cells, hematopoietic growth factors, lymphoid organs (primary and secondary) and cells, mononuclear cells, granulocytic cells, mast cells, dendritic cells- characteristics and functions. **(3)**

3. Types of Immunity: (i) Innate immunity and Adaptive immunity, Major Histocompatibility Complex (MHC) and their role in antigen presentation, cytokine. **(3)**

4. Antigens: Chemical nature, antigenicity, immunogenicity, hapten, epitopes, mitogens (definition, properties, examples); adjuvant (definition, examples, function). **(4)**

5. Immunoglobulins: Types, monoclonal and polyclonal antibody (definition and characteristics). **(4)**

6. Complement: Components, function, mode of action. **(2)**

7. Antigen - Antibody interactions: Agglutination, precipitation, immunodiffusion, immuno-electrophoresis. **(3)**

8. Hypersensitivity: Definition, types, examples. **(2)**

9. Vaccines: Active and passive immunization (definition, characteristics, examples and functions). Attenuated and inactivated viral or bacterial vaccines (definition, characteristic, functions, examples). **(3)**

10. Diagnostic immunology: ELISA, RIA, Immunofluorescence, Flow cytometry, Fluorescence activated cell sorting (FACS). **(5)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT4.3	**Intellectual Property Rights**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Intellectual Property Rights

1. Introduction: Meaning and forms of Intellectual Property Rights; International Conventions; World Intellectual Property Organisation; Indian scenario. **(2)**

2. Copyright: Background; Content and substance; Period and assignment of copyright; Infringement and remedies; penalties. **(2)**

3. Patents: Historical overview of Patent Law; purpose, policy and meaning of patent; objectives of Patent Law; patentability; procedure; rights and obligations of patent holder; infringement and remedies; penalties. **(6)**

4. Geographical Indications: Meaning and content; protection; procedure; period of validity; rights and obligations of registration owners; infringement and remedies; penalties. **(4)**

5. Protection of Plant Varieties & Farmers' Rights: Meaning and content; definitions; procedure; rights and privileges; compensations; compulsory licence; period of validity; revocation and cancellation of registration; infringement and remedies; penalties; National Gene Fund. **(6)**

6. Traditional Knowledge: Documentation of TK; IPR issues in protection of TK; value addition; transfer of TK. **(2)**

7. Biodiversity & Environment: Documentation; IPR issues in biodiversity conservation; Access to plant genetic resources and benefit sharing; Bioprospecting; Biopiracy; Implications in environmental policies; IPR in environmental sustainability. **(5)**

8. IP issues in Biotechnology: Patentability issues; Trade Secrets; IP management; Relevant International Treaties. **(3)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT4.4	**Mycorrhiza and Mushroom Cultivation**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Mycorrhiza and Mushroom Cultivation

1. Mycorrhizae: types, classification of Brundrett, 2004. **(4)**

2. Factors affecting mycorrhizal association. **(2)**

3. Nature of interaction, specific recognition in mycorrhizal association. **(4)**

4. Application in agriculture & forestry with special emphasis on as biofertilizer & bio-protector. **(8)**

5. Edible mushrooms: identification and nutrition value. **(2)**

6. Cultivation of button mushroom (*Agaricus bisporus*), paddy straw mushroom (*Voluariella volvacea*) and oyster mushroom (*Pleurotus sajor-caju*): compost- types and preparation, spawn and spawning, casing, and harvesting. **(8)**

7. Diseases of mushroom; crop management. **(2)**

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Course	Course Name	Points	Credits	Hrs./Wk.
BOSCT4.5	**Stress Physiology**	**50**	**2**	**2**
EVALUATION SCHEME - THEORY:	**Internal Assessment (20) + Term End Examination (30)** **TEE: 30 points**			

Theory

Points: 30 **Classes/ Semester: 30**

Stress Physiology

1. Definition and categories of abiotic stress: water stress and their impact on plant's life with regards to productivity. **(4)**

2. Salinity stress and gene expression. **(3)**

3. Oxidative stress and antioxidation strategies in plants and their cellular regulation. **(3)**

4. Transcriptome analysis in stress mediated responses to plants. **(2)**

5. Analysis of DNA markers in assisted breeding for stress tolerance. **(3)**

6. Techniques in validation of stress tolerance in plants. **(2)**

7. Temperature stress and HSPs structure and functions in plants. **(4)**

8. Development of transgenic for stress tolerance. **(3)**

9. Crop designing for stress tolerance and climate resilient plants. **(6)**

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SUGGESTED READINGS

BOHCT1.1: Biology & Diversity of Virus, Bacteria & Fungi

Virus

1. Principle of Molecular Virology (3rd edition), 2004, Alan J Cann, Elsevier Academic Press.
2. Fundamentals of Molecular Virology (2nd edition.), 2011, Nichola H. Acheson, Wiley.
3. Principle of Plant Virology (3rd edition), 2007, Astier S, Albouy J, Maury Y, Robaglia C, Lecoq H, Science Publisher
4. Introduction to Plant Viruses (2nd edition), 1987, C.L. Mandahar, S. Chand Publisher.
5. Fundamentals of Plant Viroloy (4th edition), 1992, R.C. Matthews, Academic Press.

Bacteria

1. Microbiology (5th Edition), 2001, Pelczar M.J., Adams M.R., Chan E.C.S., Krieg N.R., Tata McGraw Hill.
2. Fundamentals of Bacteriology, 1978, Salle A J. Asia TMH.
3. A Text book of Microbiology, 2004, Dubey R C, Maheswari D K, S. Chand and Co. Ltd.
4. Manual of Microbiology: Tools and Techniques, 2005, Kanika Sharma. Ane Books.
5. Focus on College Practical Microbiology, 2006, S. N. Sinha, Rita Book Agency.
6. Prescott and Dunn's Industrial Microbiology (4th edition), 1982, Samuel Cate Prescott, Cecil Gordon Dunn., AVI Pub. Co.
7. Kuby Immunology (7th edn), 2013, J.Owen, J.Punt,S. Stranford, W.H. Freeman.
8. Daniel K. Brannan, 2014, Cosmetic microbiology Publisher: Boca Raton, Fla.: CRC Press.
9. Prescott's Microbiology (9th Edition) 2014, J.M. Willey, L.M. Sherwood and C.J. Woolverton, McGraw-Hill.
10. Brock Biology of Microorganisms (13th Edition), 2010, Michael T. Madigan, John M.Martinko, Stahl David P. Clark. Benjamin Cummings.
11. Principle of Microbiology (2nd Edition), 1995, R. M. Atlas, McGraw Hill.

Fungi

1. Introduction to Fungi (3rd edition), 2007, John Webster & Roland W. S. Weber, Cambridge University Press.
2. Introductory Mycology (4th edition), 1996, C.J Alexopoulus, C.W. Mims & M.I Blackwel, John Wiley & Sons, Inc.
3. Fundamentals of the fungi (4th edition), 1996, Elizabeth Moor-Landecker, Prince Hall International, Inc.
4. The Filamentous Fungi (Volume I), Industrial Mycology, 1975, John E. Smith & David R. Berry, Edward Arnold Publishers Ltd.

BOHCT1.2: Biology & Diversity of Algae, Bryophytes & Pteridophytes

Algae

1. Algae – An introduction to phycology, 2009, Van Den Hoek, C., D. G. Mann & H. M. Jahns, Cambridge University Press.
2. Algae, 2009, Graham, Linda, J. M. Graham & L. W. Wilcox, Benjamin Cummings from Pearson Education.
3. Cryptogamic Botany, Algae and Fungi Vol. 1, 1955, Smith, G. M., Tata McGraw-Hill Publishing Company Ltd.
4. Cyanobacteria, 2006, Ray, S., New Age International Publishers, New Delhi.
5. Introduction to the algae: Structure and Reproduction, 1985, Bold, H. C. & M. J. Wynne, Prentice-Hall.
6. Phycology, 2008, Lee, R. E., Cambridge University Press.
7. Phytoplankton Ecology, 1986, Harris, G. P., Chapman & Hall.
8. Red Algae: Structure, Ultrastructure and Reproduction, 1997, Bhatia, Bela & M. R. Vijayaraghavan, APH Publication.
9. The Chlorophyta: Structure, Ultra-structure & Reproduction, 1995, Vijayaraghavan, M. R. & S. Kumari, Published by Bishen Singh Mahendra Pal Singh.

Bryophytes

1. Biology of Bryophytes, 2005, Chopra, R. N. & P. K. Kumra, New Age International, New Delhi.
2. Bryophyte Biology (2nd Edition), 2009, Goffinet, B. & A. J. Shaw, Cambridge University Press.
3. Bryophyte Ecology and Climate Change, 2011, Tuba, Z., N. G. Slack & L. R. Stark, Cambridge University Press.
4. Bryophytes: The closest relatives of land plants: A special issue of Phytotaxa, 9:1-278 (30th September, 2010) edited by Konrat, M. V., A J. Shaw & K. S. Renzaglia. available at http://www.mapress.com/phytotaxa/content/2010/pt00009.html
5. Cryptogamic Botany, Bryophyte & Pteridophyte Vol. 2, 1995, Smith, G. M., Tata McGraw-Hill Publishing Company Ltd.
6. Introduction to Bryophytes, 2009, Vanderpoorten, A. & B. Goffinet, Cambridge University Press.

Pteridophytes

1. Fern Ecology. 2010. Mehltreter Klaus, Walker, R. Lawrence, Sharpe, Joanne M. Cambridge University Press.
2. Working with Ferns. 2010. Fernández, H. and Revilla, M. A. Springer.
3. The Ferns (Vol. I, II, III). 1939. Bower, F. O. Today and Tomorrow's Printers, New Delhi.
4. The Experimental Biology of Ferns. 1979. Dyer A. F. Academic Press, London, New York.
5. Morphology of Vascular Plants – Lower Groups. 1936. Eames, A. J. Tata McGraw Hill, New Delhi.

6. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S W H Freeman and Company, New York.
7. The Families and Genera of Vascular Plants. 1990. eds. Kubitzki, K., Vol. I by Kramer K.U. (Editor), Green, P.S. (Editor), Gotz, Erich (Illustrator). Springer.
8. An Introduction to Pteridophyta: Diversity, Development, Differentiation. 2009. Rashid, A. Vikas Publishing House Pvt. Ltd, New Delhi.
9. Cryptogamic Botany. Vol. II. Bryophytes and Pteridophytes. 1971. Smith, G. M. Tata McGraw Hill, New Delhi.
10. The Morphology of Pteridophytes. 1991. Sporne, K.R. B.I. Publishing Pvt. Ltd., Bombay.

BOHCT1.3: Taxonomy of Angiosperms & Biosystematics

1. Evolution and Classification of Flowering Plants. (1st & 2nd edn), 1968 & 1988, Cronquist, A. The New York Botanic garden, New York.
2. An Integrated System of Classification of Flowering Plants, 1981, Cronquist, A, Columbia University Press, NewYork.
3. The Families of Monocotyledons: A Comparative Study. 1985. Dahlgren, R.M.T., Clifford, H.T. and Yeo, P.F., Springer Verlag, Berlin.
4. Principles of Angiosperm Taxonomy. 1963. Davis. P.H. and Heywood, Robert. E. Krieger Publishing Company, New York.
5. An aid to the International code of Botanical Nomenclature. 1985. Henry, A. N. and Chandrabose, M., Today & tomorrow's printers & publishers.
6. A Handbook of Field and Herbarium Methods. 1977. Jain, S.K. and Rao, R.R. Today and Tomorrow's Printers and Publishers, New Delhi.
7. Plant Systematics. (2nd Edition) 1987. Jones, S. B. Jr. and Luchsinger, A. E. Mc Graw-Hill Book, Co. New York, The Macmillan Co., Ithaca, New York.
8. Plant Systematics: a Phylogenetic Approach. (3rd Ed.) 2008. Judd, W. S., Campbell, C. S., Kellogg, E.A., Stevens, P.F. and Donoghue, M. J., Sinauer Associates, INC., Sundarlands.
9. Plant Systematics. (1st & 2nd Ed.) 2006 & 2010. Simpson, M. G., Elsevier Academic Press, London.
10. Plant Systematics: (2nd Ed.). 2012. An Integrated Approach. Singh, Gurcharan, Oxford and IBH Publishing Co. New Delhi.
11. Principles of Plant Taxonomy. 1984. Sivarajan, V. V. Oxford and IBH publishing Co. New Delhi.
12. Plant Taxonomy and Biosystematics. (2nd Edn.). 1989. Stace, C. A., Cambridge University Press.
13. Plant Taxonomy: (2nd Ed). 2009. The Systematic Evaluation of Comparative Data. Stuessy, Tod F., Columbia University, Press, New York

14. Diversity and Classification of Flowering Plants. 1997. Takhtajan, A., Columbia University Press, New York.

BOHCT1.4: Cytology, Cytogenetics & Genetics

1. Concepts of Genetics - 2012, King W.S., Cummings M.R., Spencer C.A. & Palladino M.A. Pearson International.
2. Essential Genetics- A Genomic Perspective - 2011, Hartl D.L. & Elizabeth W.J. Jones & Bartlett publishers.
3. Genes XI - 2013, Benjamin L. Jones & Bartlett publishers.
4. Genetics - A Conceptual Approach- 2011, W.H. Freeman & Company.
5. Genetics - Analysis of genes and Genomes - 2012, Daniel L. Hartl Jones & Bartlett Learning publishers.
6. Genetics - from genes to genomes - 2012, Hartwell L. Tata McGraw-Hill International.
7. *i*Genetics - A Molecular Approach- 2011, Russell, P.J. Pearson International.
8. Molecular Cell Biology – Lodish H., Berk A., Lawrence S., Zipursky, Matsudaira P., Baltimore D. and Darnell J.W.H. Freeman publisher.
9. Principles of Gene Manipulation & Genomics - 2011, Primose S.B. & Twyman R. Wiley-Blackwell.
10. Principles of Genetics - 2012, Snustad P., Simmons M.J. Wiley International.
11. Principles of Genetics - 2012, Tamarin R.H. Tata McGraw-Hill International.
12. Cell and Molecular Biology: 2011, Karp G. Wiley publisher.
13. The Cell - A Molecular Approach. 2011, Cooper G.M. Sinauer Associates, Inc.
14. Molecular Biology of the Cell, 2011, Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P. Garland Science.
15. Cell and Molecular Biology: 2001, De Robertis E.D.P., De Robertis E.M.F. Lippincott Williams & Wilkins.
16. Molecular Biology genes to Proteins - 2013, Burtan E.T. Jones and Bartlett Publishers.
17. The Molecular Life of Plants - 2013 Jones R., Pugham H., Thomas H., Wauland S. Willey-Blackwell.
18. Introduction to genetic analysis - 2011 Griffith A.J.F., Wessler S.R., Carroll S.B., Doebley J. W.H. Freeman.
19. Genome 3 - 2012 Brown T.A. Garland Science Publishing.
20. Plant chromosome: Analysis, manipulation and Engineering- 1999 Sharma A.K. & Sharma A Harwood Academic Publishers.
21. Chromosome Techniques, Theory and practice- 1998 Sharma A.K. & Sharma A. Butterwatch.

BOHCT2.1: Biology & Diversity of Gymnosperms, Palaeobotany & Palynology

Gymnosperms

1. Gymnosperms. 1996. Bhatnagar S.P and Moitra Alok. New Age International Pvt. Ltd. Publishers, New Delhi.
2. Morphology of Vascular Plants. 1971. Bierhorst D.W. New York and London.
3. The Gymnosperms. 2004. Biswas C and Johari B.M. Narosa Publishing House, New Delhi.
4. Gymnosperms Structure and Evolution. 1957. Chamberlain, C. J. Dover Publications, Inc. New York.
5. Morphology of Gymnosperms. 1967. Coultar, J. M. and Chamberlin, C. J. Central Book Depot, Allahabad.
6. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S W H Freeman and Company, New York.
7. The Families and Genera of Vascular Plants. 1990. eds. Kubitzki, K., Vol. I by Kramer K.U. (Editor), Green, P.S. (Editor), Gotz, Erich (Illustrator). Springer.
8. The Morphology of Gymnosperms. 1965. Sporne K.R. Hutchinson University Library, London.

Palaeobotany

1. An Introduction to Palaeobotany. 2000. Arnold A. C. Agrobios (India), Jodhpur.
2. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S W H Freeman and Company, New York
3. Fundamentals of Palaeobotany. 1987. Meyen S. V. Chapman and Hall Ltd., New York.
4. The Evolutionary Biology of Plants. 1997. Niklas, K. J. The University of Chicago Press, London
5. Fossil plants: for students of botany and geology. Vol. I, II, III and IV. 1963. Seward, A**.** C. New York: Hafner Publishing Co.
6. Paleobotany and the Evolution of Plants. 1993. Stewart, W.N. and Rathwell, G.W. Cambridge University Press.
7. Palaeobotany-The Biology and Evolution of Fossil Plants. 2009. Taylor Thomas N., Taylor Edith L. and Krings Michael. Academic Press, Elsevier.
8. The Evolution and Palaeobiology of Land Plants. 1986. Thomas Barry A. and Spicer Robert A. Croom Helm, London and Sydney.
9. Palaeopalynology. 2007. Traverse Alfred. Springer.
10. The Evolution of Plants. 2005. Willis K. J. and McElwain J. C. Oxford University of Press.

Palynology

1. A Textbook of Palynology (Basic and Applied). 2006, Kashinath Bhattacharya, Manas Ranjan Majumdar & Swati Gupta Bhattacharya, New Central Book Agency (P) Ltd.

2. Evolutionary Significance of the Exine (Linnean Society Symposium). 1976. Ian Keith Ferguson (Editor), Jan Muller (Editor). Academic Press Inc
3. Handbook of Palynolgy. 1969. Erdtman G. Munksgaard, Copenhagen.
4. Palaeopalynology 2nd ed. 2007. Traverse Alfred. Springer
5. Palynology, A treatise, 1993, M.R. Saxena, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Pollen Analysis. 1991. Moore, P. D., Webb, J. A. and Collinson, M. E. Blackwell Science Ltd. London.
7. Pollen morphology and Plant Taxonomy. 1952. Erdtman G. Almquist & Wiksell, Stockolm
8. Pollen and Pollination. 2000. Dafni A., Hesse, M. and Pacini E. (eds). SpringerWien New York.
9. Pollen and spores: Form and function. 1987. Blackmore, S., and IK Ferguson (eds.), Academic Press, London
10. Textbook of modern Pollen Analysis. 1975. Faegri, K. and Iverson, J. Munksgaard, Copenhagen.

BOHCT2.2: Plant Physiology & Biochemistry

1. Biochemistry (7th edition), 2010, Jeremy M Berg John L Tymoczko and Lubert Stryer, W. H. Freeman.
2. Plant Physiology, 1985, Frank B. Salisbury, Cleon W. Ross; Wadsworth Pub. Co.
3. Plant Physiology, 5th edition, 2010, Lincoln Taiz, Eduardo Zeiger, Sinauer Associates Inc Publishers.
4. Advance in Plant Physiology, 2006, P C Trivedi; I K International Publishing House.
5. Plant Biochemistry, 1997, P.M. Dey and J.B. Harborne; Academic Press.
6. Biochemistry, 5th edition, 2013, Reginald H. Garrett, Charles M. Grisham. Cengage Learning.
7. Principle of Biochemistry, 6th edition 2012, David L. Nelson and Michael M. Cox; W.H Freeman Publisher.
8. Introduction to Plant Physiology, 4th edition, 2009, William G. Hopkins, Norman P. A. Hüner, Wiley.
9. A Text book of Plant physiology, Biochemistry and Biotechnology, 2007, S. Verma and M. Verma, S. Chand Publisher.
10. Biochemistry,7th edition, 2012, Mary K. Campbell, Shawn O' Farrell, Cengage Learning.
11. Harper's Illustrated Biochemistry, 29th edition, 2012, R K Murray, D. Bender, K. M. Botham, P. J. Kennelly, V. Rodwell, P.A. Weil. McGraw Hill.
12. Outlines of Biochemistry 5th edition, 2006, E.E. Conn, P. K. Stumpf, G. Bruening, R. H. Doi, John Wiley.

BOHCT2.3: Plant Anatomy, Economic Botany & Pharmacognosy

Plant Anatomy

1. An introduction to plant structure and development. (2nd Ed) 2010. Beck Charles B. Cambridge University Press.
2. Plant Anatomy. 2001. Pandey B. P., S. Chand Publisher.
3. Plant Anatomy. 1990. Fahn, A. Pergamon Press.
4. Plant Anatomy. Katherine Esau (2nd Ed) 2006. John Wiley & Sons.
5. Anatomy of Seed Plants (2nd Ed) 1977. Katherine Esau Wiley India Pvt. Ltd.
6. Plant Anatomy: 2008. An Applied Approach . Cutler D. F., Ted Botha and Dennis Wm. Stevenson Wiley Blackwell.
7. Plant Anatomy and Embryology. (2nd Ed) 1997. Chadha A., Pandey S. N., Sangam Books Ltd.

Economic Botany

1. The Useful Plants of India. Ambasta, S.P. 1986. Publications and Information Directorate, CSIR, New Delhi.
2. Economic Botany: A Text Book of Useful Plants and Plants Products. (2nd Ed) 1952. Hill. A. F. McGraw Hill Book Co., Inc. New York.
3. Economic Botany in the Tropics. 2009. Kochhar, S. L. Macmillan India Ltd. Delhi.
4. Tribe Medicine. 1998. Pal, D.C. and Jain, S.K. Naya Prakash, Kolkata.
5. A Text Book of Economic Botany. 1989. Sambamurthy, A.V.S.S. and Subrahmanyam, N.S. New Delhi.
6. Economic Botany: Principles and Practices. 2001. Wickens, G. E. Springer.

Pharmacognosy

1. Text Book of Pharmacognosy, 2007, Mohammed Ali, CBS Publishers and Distributors.
2. Trease and Evans' Pharmacognosy (15th Reprint Edn), 2006, Evans, W.C. Elsevier Publication.
3. Textbook of Pharmacognosy (2nd Edn), 1995, Handa, S.S. and Kapoor,V.K.. , Vallabh Prakshan, Delhi.
4. Dictionary of Indian Folk Medicine and Ethnobotany, 1996, Jain S. K, Deep Publications, New Delhi.
5. Medicinal Plants, 1968, Jain S.K, National Book Trust, New Delhi.
6. Pharmacognosy (46th Edn.), 2010, Kokate C. K, Purohit A. P. and Gokhale S. B, Nirali Prakashan.
7. Practical Pharmacognosy, 4th edn.), Saber A.H. , Alshaab Printing House, Cairo.
8. A Photochemical Approach to Economic Botany, 1991, Sabnis S.D. and Daniel, Kalyani Publishers.
9. Ethnobiology, 2001, Sinha R. K. and Sinha S, Surabhi Publications, Jaipur.

10. A Text Book of Pharmacognosy (6th edn.), ,Trease G. E. ,Bailliere, The New York Botanic garden, New York 1st & 2nd edn.
11. Pharmacognosy(9th Edition),1988, Tyler Varro E , Brady Lynn R & Robbers James E , Lea & Febiger Publisher.
12. Text Book of Pharmacognosy, 1967, Wallis T. E, J and A Churchil Ltd., London.

BOHCT2.4: Plant Embryology, Plant Breeding & Biometry

1. The Embryology of Angiosperm. 2012. Bhojwani S.S. and Bhatnagar S.P. Vikas Publishing House Pvt. Ltd.
2. Current trends in Embryology. 2012. Bhojwani S.S. Kluewar Publication.
3. Plant developmental Biology. 2012. Pua E.C. and Davey M.R. Springer.
4. Developmental Biology. 2013. Twyman R.M. Viva Books Pvt. Ltd.
5. Plant Breeding. Molecular and new approaches. 2013. Singh Phundan. Kalyani Publishers.
6. Breeding Field Crops. 2010. Chopra V.L. Oxford IBH.
7. Crop Breeding and Genetics 2013. Ram H.H. and Singh H.G. Kalyani Publisher.
8. Principles of Plant Breeding. 2011. Allard R.W. John Wiley & Sons.
9. Plant Breeding. 2010. Poehlman J.M. & Barthakur D. Oxford & IBH.
10. Plant Breeding. 2012. Principles and Methods, Singh B.D. Kalyani Publishers.
11. Principles and Practice of Plant Breeding. 2012. Sharma J.R. Tata McGraw Hill.
12. Molecular Plant Breeding. 2010. Yunbi Xu. Cabi Publishing.
13. An Introduction to Plant Breeding. 2010. Brown jack, Oaligari Peter. Wiley-Blackwell.
14. Molecular Marker Systems in Plant Breeding and Crop Improvement. 2010. Lorz, Horst; Wendel, Gerhard (lids.). Springer.
15. Botanical Microtechnique: principles and Practice. 2002. Khasim, S.M. Capital publishing Company.
16. Basic Biostatistics and its Application: 2007. Datta A. K., Central Book Agency, Kolkata.
17. Statistical Methods I and II: 2008. Das N. G. Tata McGraw - Hill Education.

BOHCT3.1: Principles of Plant Pathology & Crop Protection

1. Plant Pathology (5th edition), 2005, G.N. Agrios, Academic Press, London.
2. Plant Pathology, 1980, R.S. Mahrotra, Tata McGraw- Hill Publishing Company Ltd.
3. Introduction to Principles of plant pathology (3rd edition), 1975, Oxford & IBH Publishing Co. Pvt. Ltd.

4. Outlines of Plant Pathology, 1970, Gary A. Strobel& Don E. Mathre, Van Nostrand Reinhold Company.
5. Diseases of Crop Plants, 2006 (4th edition), G. Rangaswami & A. Mahadevan, Prentice Hall, India.
6. Plant Diseases, 2009, R. S. Singh, Oxford & IBH Publishing Co. Pvt. Ltd.

BOHCT3.2: Principles of Plant Ecology & Biodiversity, Conservation

Principles of Plant Ecology

1. Population Ecology. Second Edition. (1997). By M. Begon & M. Mortimer Blackwell Scientific Publications.
2. Ecology: Principles and Applications. Second Edition. (2005). By J. L. Chapman & M. J. Reiss Cambridge University Press.
3. Ecology of Aquatic Systems. (2009). M. Dobson & C. Frid, Oxford University Press.
4. Concepts of Ecology. Third Edition. (1991). Edward J. Kormondy, Prentice-Hall of India.
5. Measuring Biological Diversity. (2003). A. E. Magurran, Wiley-Blackwell Publishing.
6. Fundamentals of Ecology. (1971). E. P. Odum, W.B. Saunders, Philadelphia.
7. Climatology: An atmospheric science. Second Edition, (2011). J. E. Oliver & J. J. Hidore Pearson Education, New Delhi.
8. Environmental Pollution: Health and Toxicology. Second Edition. (2011). S. V. S. Rana, Narosa Publishing House.
9. Ecology. Fourth Edition. (2000). R. E. Ricklefs and G. L. Miller, W. H. Freeman and Co., New York.
10. Ecology and Field Biology. Sixth Edition. (2001). T. M. Smith & R. L. Smith Prentice Hall.
11. Elements of Ecology. Sixth Edition. (2006). T. M. Smith & R. L. Smith Pearson Education, Inc.
12. Ecology: Theories and Applications. Fourth Edition. (2002). P. Stiling, Prentice-Hall, Inc.
13. Plant Ecology. (2005). E. D. Schulze, E. Beck & K. Muller-Hohenstein Springer Publication.
14. Ecological Methods. (2000). T. R. E. Southwood & P. A. Henderson. Third Edition. Wiley-Blackwell Publishing House.
15. Ecology. Second Edition. (2008). N. S. Subrahmanyam & A. V. S. S. Sambamurty Narosa Publishing House.
16. Essentials of Ecology. Third Edition. (2005). Tyler Miller Jr., G. Thomson Learning, Inc.

Applied Ecology

1. Global Biodiversity Assessment (1995). V. H. Heywood Cambridge University Press, Cambridge.
2. Textbook of Biodiversity. (2003). K. V. Krishnamurthy, Science Publishers.
3. Biodiversity, Biotechnology and Traditional Knowledge: Understanding Intellectual Property Rights. (2010). A. Kumar & G. Das Narosa Publishing House, New Delhi.

4. Climate change and Biodiversity. (2006). Lovejoy, T. E. & L. Hannah Yale University Press.
5. Measuring Biological Diversity. (2003). A. E. Magurran, Wiley-Blackwell Publishing.
6. Mapping the Diversity of Nature. (1994). R. I. Miller, Chapman and Hall, London.
7. Hotspots of Endemic Plants of India, Nepal and Bhutan. (1996). M. P. Nayar, Tropical Botanical Garden and Research Institute, Thiruvananthapuram.
8. Biodiversity: status and prospects. (2005). P. Tandon, Manju Sharma & Renu Swarup (eds.) Narosa Publishing House, New Delhi.
9. The Diversity of Life. (2010). E. O. Wilson, W. W. Norton & Co. Inc. New York.
10. Red Data Book of Indian Plants Vol. 1 to 5. (1987). M. P. Nayar & A. R. K. Sastry BSI, Calcutta.
11. Principles of Environmental Science. (2007). W. P. Cunningham and M. A. Cunningham, Tata McGraw Hills.
12. Environmental Pollution: Health and Toxicology. (2011). S. V. S. Rana, Alpha Science International Limited.
13. Essentials of Conservation Biology. Richard B. Primack. Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
14. Pollution: Causes, Effects and Control. Roy M. Harrison (Editor), Publisher: Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge, UK.
15. Environmental Pollution Studies- by Gerald Arthur Best, Liverpool University Press.

BOHCT3.3: Molecular Biology & Biotechnology

1. Cell and Molecular Biology 1st Edition, 2008, Khanna P, I K International Publishing House.
2. Molecular Biology of the Cell 5 edition, 2007, Alberts B, Garland Science.
3. Methods in Molecular Biology, Walker JM, Springer.
4. The Molecular Biology of Plant Cells, 1978, Smith H, University of California Press.
5. Molecular Cell Biology (Lodish Molecular Cell Biology) 7th edition, 2012, Lodish Harvey, Berk, Arnold, Kaiser, Chris A., Krieger Mon, W. H. Freeman.
6. Molecular Biology 5 edition, 2011, Weaver R, McGraw-Hill.
7. Plant tissue Culture: An Introductory Text, 2013, S. S. Bhojwani and P. K. Danta, Springer.
8. Plant Biotechnology, 2012, K.G. Ramawat , S. Chand Publication.
9. Plant Biotechnology, 2012, H.S.Chawla , Oxford IBH.
10. Plant Biotechnology, 2012, B.D.Singh , Kalyani publisher.
11. Plant Biotechnology –A Practical manual, 2009, C.C.Giri and Archana Giri , I.K International.
12. Practical Biotechnlogy, 2011, S. Janar Thanan and S. Vincent, Universities Press.

13. Plant Tissue Culture: Theory and Practice revised edition, 1996, Bhojvvani, S.S. and Razdan, M.K, Elsevier Science Publishers, New York, USA.
14. Plant Propagation by Tissue Culture 3rd Edition, George L.F, Hall MA. and Klerk J.D. , Springer.
15. Plant Tissue Culture: Techniques and Experiments, 1999, Hall. R.D, Academic Press, New York.
16. Botanical Microtechnique. Principles and Practice, 2002, Khasim, S.M, Capital Publishing Company. New Delhi.
17. Plant tissue Culture: An Introductory Text, 2013, S. S. Bhojwani and P. K. Danta, Springer.
18. Biochemistry, 4th edition, 2010, Donald Voet, Judith G. Voet, John Wiley and sons.
19. Biochemistry & Molecular Biology of Plants, 2002, Bob Buchanan, Wilhelm Gruissem, Russell Jones , Wiley.
20. Molecular Biology, 2nd edition, 2012, David P. Clark, Nanette J. Pazdernik, Elsevier pulisher.
21. Principle of Biochemistry, 6th edition 2012, David L. Nelson and Michael M. Cox, W.H Freeman Publisher.
22. Principles and techniques of biochemistry and Molecular Biology 7th edition, 2010, Keith Wilson and John Walker, Cambridge University Press.
23. Microbial Biotechnology 2nd edn, 2007, Glazer &Nikaido, Cambridge University Press.
24. Microbial Biotechnology, Principle and Application, 2006, Y.K.Lee, World Scientific Publishing.

BOSCT3.1: Environmental Biology

1. Environmental Biology. 2002. Allan and Jones. Taylor & Francis.
2. The Chemistry and Microbiology of pollution. 1975. I. J. Higgins and R. Burns. Academic Press Inc
3. Modern concepts in Ecology. 1975. H. D. Kumar. Vikas Publishing House Pvt Ltd.

BOSCT3.2: Forensic Botany

1. Forensic Botany: A Practical Guide. 2012. Hall David W., Byrd, Jason. Wiley-Blackwell
2. Forensic Botany: Principles and Applications to Criminal Caseworks. 2005. ed. Heather Miller Coyle. CRC Press, New York.

BOSCT3.3: Industrial Microbiology

1. Industrial Microbiology. (1999). Casida. LE, New age International (P) Limited, Publishers.
2. Industrial Microbiology. (2000). A.H. Patel. Macmillan Publishers India.
3. Principles of Fermentation Technology. P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.

4. A text book of Industrial Microbiology. (1989). Wulf Crueger and Anneliese Crueger, Panimam Publishing Corporation.
5. Biology of Industrial microorganisms. (1981). Arnold L. Demain. Benjamin/Cummings Pub. Co., Advanced Book Program.
6. Biotechnology: a text book of industrial microbiology. (1990). Wulf Crueger, Anneliese Crueger, Thomas D. Brock.

BOSCT3.4: Medical Mycology

1. Medical mycology, 2006, Dr. N.C. Dey, Dr. H.L.E. Grueber & Dr. T.K.Dey, New Central Book Agency (P) Ltd.
2. Fundamental Medical Mycology , 2011, Errol Reiss, H. Jean Shadomy, G. Marshall Lyon, Wiley-Blackwell

BOSCT3.5: Molecular Genetics

1. Concepts of Genetics- 2012 King, W. S., Cummings M.R., Spencer C.A. & Palladino M.A. Pearson International.
2. Essential Genetics- A Genomic Perspective- 2011, Hartl,D.L. & Elizabeth,W.J. Jones & Bartlett publishers.
3. Genes XI- 2013 Benjamin L. Jones & Bartlett publishers.
4. Genetics- from genes to genomes- 2012 Hartwell, L. Tata McGraw-Hill International.
5. iGenetics- A Molecular Approach- 2011 Russell, P.J. Pearson International.
6. Principles of Gene Manipulation & Genomics- 2011 Primose S.B. & Twyman R. Wiley-Blackwell.
7. Principles of Genetics- 2012 Snustad,P., Simmons M.J. Wiley International.

   Principles of Genetics- 2012 Tamarin,R.H. Tata McGraw-Hill International.

BOSCT3.6: Seed Physiology

1. Principles of Seed Science and Technology, 4th edition. 2001. Larry O Copeland and Miller McDonald Springer.
2. Seed Biology: Importance, Development and Germination v. 1 (Physiological Ecology). 1972. T.T. Kozlowski. Academic Press Inc.
3. Annual Review of Plant Biology. 2012. volume 63.
4. Seeds: Physiology of development and germination. 3rd ed. 2013. Bewly J.D, Kent Bradford, Henk Hilhorst, Hiroyuki Nonogaki. Springer.
5. Seed Physiology of Crops. 2011. M Prakash. Satish Serial Publishing House, New Delhi.

6. Physiology and Biochemistry of Seeds in Relation to Germination. Vol II. 1982. Dr. J. Derek Bewley, Dr. Michael Black. Springer Verlag, Berlin
7. Hanbook of Seed Physiology: applications to agriculture. 2004. Roberto Benech-Arnold & Rodolfo A. Senchez. Food Products Press.
8. Seed physiology Heshmat Aldesugny. http://www1.mans.edu.eg/facscim/english/courses/botany/hseldesouquy/Seedphysiology.pdf

BOECT4.1 & 4.2 (Elective Paper I &II) - <u>Genetics, Molecular Genetics, Biometry & Plant Breeding</u>

1. Concepts of Genetics- 2012 King,W.S., Cummings M.R., Spencer C.A. & Palladino M.A. Pearson International.
2. Essential Genetics- A Genomic Perspective- 2011, Hartl,D.L. & Elizabeth,W.J. Jones & Bartlett publishers.
3. Genes XI- 2013 Benjamin L. Jones & Bartlett publishers.
4. Genetics- A Conceptual Approach- 2011 W.H. Freeman & Company.
5. Genetics- Analysis of genes and Genomes- 2012 Daniel L. Hartl Jones & Bartlett Learning publishers.
6. Genetics- from genes to genomes- 2012 Hartwell, L. Tata McGraw-Hill International.
7. iGenetics- A Molecular Approach- 2011 Russell, P.J. Pearson International.
8. Molecular Cell Biology- Lodish,H., Berk,A., Lawrence,S., Zipursky, Matsudaira,P., Baltimore,D. and Darnell,J. W. H. Freeman publisher.
9. Principles of Gene Manipulation & Genomics- 2011 Primose S.B. & Twyman R. Wiley-Blackwell.
10. Principles of Genetics- 2012 Snustad,P., Simmons M.J. Wiley International.
11. Principles of Genetics- 2012 Tamarin,R.H. Tata McGraw-Hill International.
12. Plant Breeding- Molecular and new approaches- 2013 Singh,P. Kalyani Publishers.
13. Breeding Field Crops- 2010 Chopra,V.L. Oxford & IBH Publishing Company.
14. Crop Breeding and Genetics- 2013 Ram,H.H. and Singh,H.G. Kalyani Publisher.
15. Principles of Plant Breeding- 1999 Allard,R.W. Wiley.
16. Plant Breeding- 2010 Poehlman,J.M. & Barthakur,D. Oxford & IBH.
17. Plant Breeding: Principles and Methods- 2012 Singh,B.D. Kalyani Publishers.
18. Principles and Practice of Plant Breeding- 2012 Sharma J.R. Tata McGraw Hill.
19. Molecular Plant Breeding- 2010 Xu,Y. CABI Publishing House.
20. An Introduction to Plant Breeding- 2010 Brown,J. & Caligari,P. Wiley-Blackwell.

21. Molecular Marker Systems in Plant Breeding and Crop Improvement- 2010 Lorz,H. Wenzel,G. Springer.
22. Botanical Microtechnique: principle and Practices- 2002 Khasim,S.M. Capital publishing Company.
23. Basic Biostatistics and its Application- 2005 Datta, A. K.Kalyani Publisher.
24. Statistical Methods I and II- 2008 Das,N.G. Tata McGraw Hill Education Private Limited
25. Molecular Biology of the Cell- 2007 Alberts,B. Garland Science.
26. Plant tissue Culture: An Introductory Text- 2013 Bhojwani, S.S. & Danta, P.K. Springer.
27. Plant Biotechnology- B.D. Singh (Kalyani publisher, 2012).
28. Plant Tissue Culture: Theory and Practice- 1996 Bhojwani, S.S. & Razdan, M.K. Elsevier Science Publishers
29. Plant Propagation by Tissue Culture- 2011 Hall, G. & Klerk J.D. Springer.

BOECT4.3 & 4.4 (Elective Paper I &II) – Microbiology

BOECT4.3

1. Environmental Microbiology, (1st edn), 2006, R M Maier, I L Pepper, C P Gerba. Academic Press.
2. Microbial Ecology: Fundamentals and applications. (1992). 3rd Edition, Atlas, RN and Bartha R, Redwood city, Benjamin/Cummings.
3. Prescott'sMicrobiology , 2013, J.Willey, L. Sherwood, C.Woolverton., McGraw Hill.
4. Brock Biology of Microorganisms (13th edn), 2010, M.T. Madigan, J.M. Martinko, D. Stahl, D.P.Clark., Benjamin Cummings
5. Principles of Microbiology (2nd Edn), 1995, R. M. Atlas, W. C. Brown Publications
6. Alcamo's Fundamental of Microbiology ((9th Edn), 2010, Jeffrey C. Pommerville, Jones and Bartlett Publication.
7. Foundations in Microbiology: Basic Principles (8th edn), 2011, K.P.Talaro, B. Chess, McGraw Hill.
8. Microbiology: An Introduction (11th edn), 2012, G.J.Tortora, B.R.Funke, C.L.Case, Benjamin Cummings

BOECT4.4

1. Molecular Genetics of Bacteria, (1st Edn), 1997, L. Snyder, W. Champness, ASM Press, Washington DC.
2. Kuby Immunology (7th edn), 2013, J.Owen, J.Punt,S. Stranford, W.H. Freeman.
3. Cellular & Molecular Immunology (7th edn), 2011,A.K. Abbas, A.H.H. Lichtman,S. Pillai, Saunders.
4. Immunology and Immuno Technique (1st Edn), 2007, M R Pandian, B. S. Kumar, Panima Publishing Corporation (New Delhi).

5. Industrial Microbiology (1999) by Casida. LE, New age International (P) Limited, Publishers.
6. Industrial Microbiology (2000) by A.H. Patel. Macmillan Publishers India.
7. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
8. A text book of Industrial Microbiology (1989) by Wulf Crueger and Anneliese Crueger, Panimam Publishing Corporation.
9. Biology of Industrial microorganisms (1981) by Arnold L. Demain. Benjamin/Cummings Pub. Co., Advanced Book Program.
10. Biotechnology: a text book of industrial microbiology (1990); Wulf Crueger, Anneliese Crueger, Thomas D. Brock.
11. The RNA World, (1st edn), 2006, R.F Gesteland, T.R. Cech, J.F. Atkins, I K International Pvt Ltd.

BOECT4.5 & 4.6 (Elective Paper I &II) - <u>Mycology & Plant Pathology</u>

1. The Fifth Kingdom (3rd edition), 2001, Bryce Kendrick, Focus Publishing/R. Pullins Company.
2. The Fungi (2nd edition), 2001, Michael J. Carlile, Sarah C. Watkinson & Graham W. Gooday, Academic Press.
3. The Identification of Fungi: An Illustrated Introduction with Keys, Glossary, and Guide to Literature, 2006, Frank M. Dugan, APS Press.
4. Fungal Genetics, David Moore, Lily Ann Novak Frazer, Springer (Indian Reprint) 2005.
5. Fungal Biology, Deacon, Jim, Blackwell Publishing, 2005
6. Introduction to Plant Pathology Strange, RN (ed.): J. Wiley & Sons Ltd, Chichester, UK, 2003.
7. Molecular Plant Pathology, 2003, M. Dickinson, Bios Scientific Publishers Ltd.
8. Pathogenic Root-Infecting Fungi, 1969, S.D. Garrett, Cambridge University Press.
9. Seed-borne Diseases and their Control: Principles and Practice, 1996, R.B.Maude. Wallingford, UK: CAB International.
10. Plant Pathology: Principles and Practice, 1987, Jones D.G., Open University Press.
11. Plant Pathology in Agriculture, 1990, David W. Parry, Cambridge University Press.
12. Plant Disease Control: Principles and Practice (2nd edition), 1993, Otis C. Maloy, Wiley & Sons Ltd, Chichester, UK.
13. Principles of Plant Disease Management, 1982, William E. Fry, Academic Press.
14. Textbook of Modern Plant Pathology, 1998, K.S. Bilgrami & H.C. Dube, Sangam Books Ltd.
15. Fundamentals of Plant Pathology, 1973, Daniel Roberts & Carl W. Boothroyd,W.H.Freeman& Co Ltd.

BOECT4.7 & 4.8 (Elective Paper I &II) - Phycology

1. Unravelling the algae – the past, present and future of algal systematics. (2007). Juliet Brodie & Jane Lewis CRC Press.
2. Algal Chemical Ecology. (2008). C. D. Amsler, Springer.
3. Algal Culturing Techniques. R. A. Andersen, Elsevier Academic Press, London.
4. Blue green algae: Survival strategies in diverse environment. (2006). S. P. Adhikary, Pointer Publishers, Jaipur.
5. Protocols on algal and cyanobacterial research. (2010). S. N. Bagchi, D. Kleiner & P. Mohanty. Narosa Publishing House, New Delhi.
6. Freshwater algae – Identification and use as bioindicators. (2010). E. G. Bellinger & D. C. Sigee Wiley Blackwell.
7. Red Algae: Structure, Ultrastructure and Reproduction. (1997). Bela Bhatia & M. R. Vijayaraghavan. APH Publication.
8. The biology of cyanobacteria. (1982). N. G. Carr & B. A. Whitton (eds.) Blackwell Scientific Publications, Oxford.
9. Introduction to the algae: Structure and Reproduction. (1985). H. C. Bold & M. J. Wynne Prentice-Hall.
10. Seaweeds and their uses. Second Edition. (1970). V. Chapman, J. Methuen & Co. Ltd. London.
11. The Metabolism of algae. (1953). G. E. Fogg, Methuen & Co., London.
12. Algae. (2009). Linda Graham, J. M. Graham & L. W. Wilcox Benjamin Cummings from Pearson Education.
13. Phycology. (2008). R. E. Lee, Cambridge University Press.
14. The genetics of algae. (1976). Lewin, R. A. University of California Press.
15. Algae and water pollution. (1977). C. M. Palmer, USEPA, Cincinnati.
16. Cyanobacteria. (2006). S. Ray, New Age International Publishers, New Delhi.
17. Photosynthetic pigments of algae. (1989). K. S. Rowan, Cambridge University Press, USA.
18. Research Methods in Marine Biology. (1972). C. Schlieper, Sidgwick and Jackson Ltd., London.
19. Algae and cyanobacteria in extreme environments. (2007). J. Seckbach (ed.) Springer, Netherlands.
20. Phytoplankton Manual. (1978). A. Sournia (ed.) UNESCO, Paris.
21. Diatoms: Applications for environmental and earth science. (2004). E. F. Stoermer & J. P. Smol, Cambridge University Press, UK..
22. Algae – An introduction to phycology. (2009). C. Van Den Hoek, D. G. Mann & H. M. Jahns Cambridge University Press.

23. The Chlorophyta: Structure, Ultra-structure & Reproduction. (1995). M. R. Vijayaraghavan & S. Kumari Published by Bishen Singh Mahendra Pal Singh.

BOECT4.9 & 4.10 (Elective Paper I & II) - Plant Physiology, Plant Biochemistry & Plant Molecular Biology

1. Biochemistry & Molecular Biology of Plants, 2002, Bob Buchanan, Wilhelm Gruissem, Russell Jones, Wiley.
2. Biochemistry (7th edition), 2012, Jeremy M. Berg, John L. Tymoczko and Lubert Stryer, W. H. Freeman.
3. Biochemistry (7th edition), 2011, Mary K. Campbell, Shawn O. Farrell., Cengage Learning.
4. Plant Physiology (5th editon), 2010, Lincoln Taiz, Eduardo Zeiger, Sinauer Associates.Inc.
5. The Molecular Life of Plants, 2013, Russel Jones, Helen Ougham, Howard Thomas, Susan Waaland, Wiley-Blackwell.
6. Advances in Plant Physiology, 2006, P. C. Trivedi (ed.); I K International Publishing House.
7. Lehninger Principles of Biochemistry (6th edition) 2012, David L. Nelson and Michael M. Cox; W.H Freeman.
8. Thin Layer Chromatography, 1969, Egon Stahl, Springer.
9. Introduction to Plant Physiology(4th edition), 2009, William G. Hopkins, Norman P. A. Hüner; Wiley
10. Molecular Biology (2nd edition), 2012, David P. Clark, Nanette J. Pazdernik, Academic Cell.
11. Physical Biochemistry: Application to Biochemistry and Molecular Biology(2nd edition) 1982, David Freifelder, W.H. Freeman & Co.
12. Principles and techniques of Biochemistry and Molecular Biology(7th edition), 2010, Keith Wilson and John Walker, Cambridge University Press.
13. Plant Biochemistry, 1997, P.M.Dey, J.B. Harborne, Academic press.
14. Annual Review of Plant Biology.

BOECT4.11 & 4.12 (Elective Paper I &II) - Pteridology & Palaeobotany

BOECT4.11

1. Palaeobotany-The Biology and Evolution of Fossil Plants. 2009. Taylor Thomas N., Taylor Edith L. and Krings Michael. Academic Press, Elsevier.
2. Evolution. 2009. Futuyma Douglas J. Oxford University Press.
3. Palaeopalynology. 2007. Traverse Alfred. Springer.
4. The Evolution of Plants. 2005. Willis K. J. and McElwain J. C. Oxford University of Press.

5. An Introduction to Palaeobotany. 2000. Arnold A. C. Agrobios (India), Jodhpur.
6. The Evolutionary Biology of Plants. 1997. Niklas, K. J. The University of Chicago Press, London
7. Paleobotany and the Evolution of Plants. 1993. Stewart, W.N. and Rathwell, G.W. Cambridge University Press.
8. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S. W H Freeman and Company, New York
9. Fundamentals of Palaeobotany. 1987. Meyen S. V. Chapman and Hall Ltd. , New York.
10. The Evolution and Palaeobiology of Land Plants. 1986. Thomas Barry A. and Spicer Robert A. Croom Helm, London and Sydney.
11. Elements of Micropalaeontology. 1985. Bignot G. Graham & Trotman Limites, London.
12. Paleobotany, Paleoecology and Evolution. 1981. Niklas, K. J. Praeger Publishers, USA.
13. The Paleobiology of Plant Protists. 1980. Tappan H. W. H. Freeman.
14. Microfossils. 1980. Brasier M. D. George Allen & Unwin Ltd. UK.
15. Aspects and Appraisal of Indian Palaeobotany. 1974. Surange, K. R., Lakhanpal, R. N. and Bharadwaj, D. C. (ed.). Birbal Sahni Institute of Palaeobotany, Lucknow.
16. Fossil plants: for students of botany and geology. Vol. I, II, III and IV. 1963. Seward, A. C. New York: Hafner Publishing Co.
17. Studies in Paleobotany. 1961. Andrews, H. N., Jr. 1961. New York: John Wiley & Sons Inc.
18. Catalogue of fossil spore and pollen. 1957-1967. Kremp G. O. W. et. al. Pennsylvania State University.
19. Plant Life through the Ages. 1931. Seward, A. C. Cambridge University Press, London.

BOECT4.12

1. Fern Ecology. 2010. Mehltreter Klaus, Walker Lawrence R. and Sharpe Joanne M. Cambridge University Press.
2. Working with Ferns: Issues and Applications. 2010. Fernandez Helena, Kumar Ashwani, Revilla Maria Angeles. Springer
3. An Introduction to Pteridophyta: Diversity, Development, Differentiation. 2009. Rashid, A. Vikas Publishing House Pvt. Ltd, New Delhi.
4. Paleobotany and the Evolution of Plants. 1993. Stewart, W.N. and Rathwell, G.W. Cambridge University Press.
5. The Families and Genera of Vascular Plants. 1990. eds. Kubitzki, K., Vol. I by Kramer K.U. (Editor), Green, P.S. (Editor), Gotz, Erich (Illustrator). Springer.
6. Spores of the Pteridophyta: Surface, Wall Structure and Diversity based on Electron Microscope Studies. 1990. Tryon A. F. and Lugardon B. Springer-Verlag, New York.

7. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S. W H Freeman and Company. New York.
8. Ferns and allies, Plants with special reference to Tropical America. 1982. Tryon Rolla M. and Tryon Alice F. Springer-Verlag, New York, Heidberg, Berlin
9. The Experimental Biology of Ferns. 1979. Dyer A. F. Academic Press, London, New York.
10. Comparative Anatomy of Vegetative Organs of the Pteridophytes. 1972. Ogura Y. GebrÜder Borntraeger, Berlin.
11. Spore Discharge in Land Plants. 1939. Ingold, C. T. Oxford, UK.
12. Morphology of Vascular Plants – Lower Groups. 1936. Eames, A. J. Tata McGraw Hill, New Delhi.

Journals

American Fern Journal

Botanical Review

Geophytology

Grana

Indian Fern Journal

Journal of Micropalaeontology

Palaeogeography, Palaeoclimatology, Palaeoecology

Palynology

Palynos

Pollen et. Spores

Review Palaeobotany Palynology

The Palaeobotanist

BOECT4.13 & 4.14 (Elective Paper I &II) - Taxonomy of Angiosperms & Biosystematics

1. Manual of Cultivated Plants. (2nd Rev. edn.), 1949, Bailey L.H., The Macmillan Co., New York.
2. Flowering Plants - Taxonomy and Phylogeny. 1998, Bhattacharyya, B. and B. M. Johri, Narosa Publishing House, New Delhi.
3. Evolution and Classification of Flowering Plants. 1968 and 1988 (1st & 2nd edn.), Cronquist A. The New York Botanic Garden, New York
4. An Integrated System of Classification of Flowering Plants. 1981. Cronquist, A., Columbia University Press, New York.
5. The Identification of Flowering Plant Families (2nd edn.). 1979. Davis, P. H. and Cullen, J., Cambridge University Press. London.

6. Principles of Angiosperm Taxonomy. 1963. Davis. P.H. and Heywood, Robert. E. Krieger Publishing Company, New York.
7. An aid to the International code of Botanical Nomenclature. 1985. Henry, A. N. and Chandrabose, M., Today & tomorrow's printers & publishers.
8. Flowering Plants of the World. 2007. Heywood, V.H., Brummitt, R.K. Culham, A. and Sinauer O., Firefly Books, London.
9. A Glossary of Botanic Terms. 1960. Jackson, B.D., J.B. Lippincott Company.
10. A Handbook of Field and Herbarium Methods.1977. Jain, S.K. and Rao, R. R.,Today and Tomorrow's Printers and Publishers, New Delhi.
11. Glimpses of Indian Ethnobotany. 1981. Jain, S.K. (ed.), Oxford & IBH Publishers House.
12. Plant Systematics: A Phylogenetic Approach. (3rd edn.), Judd, Walter S. ,Nickrent, Daniel, L., Robertson, Kenneth, R., Abbott, J. Richard Campbell, Christopher, S. Carlsward, Barbara, S. Donoghue, Michael, J. and Kellogg, Elizabeth A., Sinauer Associates , INC, Sunderland, USA.
13. Mabberley's Plant Book. (3rd edn.), 2008. Mabberley, D. J., Cambridge University Press. Cambridge.
14. Perspectives of Plant Taxonomy, Exploration, Herbarium, Nomenclature and Classification. 2012, Naya Udyog, Kolkata.
15. Vascular Plant Systematics. Radford, 1974, A. E., Dickison, W. C , Massey, J.R. and Bell, C.R Harper & Row, New York.
16. Biodiversity in India (Plant Aspects). 1994, Rao, R. R., Bishan Singh Mahandrapal Singh, Dehradun.
17. Plant Systematics. (1st & 2nd edn.). 2006 & 2010, Simpson, M. G., Elsevier Academic Press, London.
18. Plant Systematics: An Integrated Approach. (3rd edn.) 2012, Singh, Gurcharan, Science Publishers, Enfield.
19. Angiosperm Phylogeny and Evolution. 2005. Soltis, D.E., Soltis, P.S.,Endress, P.K. and Chase, M.W., Sinauer, Sundarland, New York.
20. Plant Taxonomy and Biosystematics. (2nd edn.), 1989. Stace, C. A., Cambridge University Press.
21. Plant Taxonomy: The Systematic Evaluation of Comparative Data. (2nd edn.). 2009, Stuessy, Tod F., Columbia University Press, New York.
22. Diversity and Classification of Flowering Plants. 1997. Takhtajan, A., Columbia University Press, New York.
23. The Principles of Dispersal of Higher Plants. 1982. Van der Pijl, L., Springer.Verlag, Berlin.

BOSCT4.1: Evolution

1. Hall, K. Brian, Hallgrimsson, Benedikt. 2014. Strickberger's Evolution. Jones and Barlett Learning, Burlington, USA.
2. Futuyma Douglas J. 2009. Evolution. Oxford University Press.
3. Niklas, K. J. 1997. The Evolutionary Biology of Plants. The University of Chicago Press, London
4. Strickberger W. Monroe. 1990. Evolution. Jones and Bartlett.

BOSCT4.2: Immunology

1. Kuby Immunology (7th edn), 2013, J.Owen, J.Punt,S. Stranford, W.H. Freeman.
2. Cellular & Molecular Immunology (7th edn), 2011, A.K. Abbas, A.H.H. Lichtman, S. Pillai, Saunders.
3. Immunology and Immuno Technique (1st Edn), 2007, M R Pandian, B. S. Kumar, Panima Publishing Corporation (New Delhi).

BOSCT4.3: Intellectual Property Right

1. Biodiversity, Biotechnology and Traditional Knowledge: Understanding Intellectual Property Rights by Kumar, A. & G. Das (2010). Narosa Publishing House, New Delhi.
2. Text Book on Intellectual Property Rights (2nd Edition) by Acharya, N. K. (2004). Asia Law House, Hyderabad.
3. Intellectual Property Law in India by Tamali Sen Gupta (2011). Kluwer Law International, Netherland.
4. Intellectual Property Rights, Trade and Biodiversity: Seeds and Plant Varieties by G. Dutfield (2000). Earthscan Publications, UK.
5. The Role of Intellectual Property Rights in Biotechnology Innovation by David Castle (2009). Edward Elgar Publishing, UK

BOSCT4.4: Mycorrhiza & Mushroom Cultivation

1. Basic Research and Applications of Mycorrhizae, 2007, ed. Gopi K. Podila & Arijit Varma, I.K. International Pvt. Ltd.
2. Arbuscular Mycorrhizae Interactions in Plants, Rhizosphere and soils, 2002, Ed A.K. Sharma & B.N. Johri, Oxford & IBH Publishing Co. Pvt. Ltd.

BOSCT4.5: Stress Physiology

1. Plant Physiology: International Edition (5th Edition). 2010. Lincoln Taiz and Eduardo Zeiger. Sinauer Associates Inc.,U.S.

2. Plant Physiology: The Structure of Plants. 2007. Explained by (author) Edwin Oxlade, Edited by Dr. Graham Lawler. Studymates.
3. Plant Physiology (4^{th} revised edition). 1991. Frank Boyer Salisbury, Cleon Ross. Brooks/Cole.
4. Physiology and Behaviour of Plants. 2008 Peter Scott. Wiley-Blackwell.
5. Introduction to Plant Physiology (4th Edition). 2008. William G. Hopkins, Norman P.A. Huner. John Wiley & Sons.
6. Plant Physiology. 2010. Edited by Hans Mohr and Peter Schopfer, Translated by G. Lawlor and D.W. Lawlor. Springer-Verlag Berlin and Heidelberg GmbH & Co.