



Tripura University

(A Central University)

Suryamaninagar

West Tripura

Syllabus for
Four Years Undergraduate Programme
Subject: Botany (Major)
(As per NEP-2020)

Year - 2023



Tripura University
(A Central University)

Course Structure of Botany (UG Programme)
As per NEP-2020 under Tripura University

BOTANY MAJOR

Year	Semester	Paper	Credits	Mark	Unit - I	Unit - II	Unit-III	Unit-IV
1 st	1 st BT101C	Paper-1 Theory	4	100 (IA=40 + ESE=60)	Microbiology-I	Microbiology-II	Phycology-I	Phycology-II
	1 st BT102C	Paper-2A Theory	2	60 (IA=24 + ESE=36)	Mycology-I	Mycology-II	Mycology-III	Lichen, Myxomycetes & Mycorrhiza
		Paper-2B Practical	2	40 (IA=16 + ESE=24)	Based on Theory paper 1 & 2A			
	2 nd BT201C	Paper-3 Theory	4	100 (IA=40 + ESE=60)	Bryophyta	Pteridophyta	Gymnosperms	Basic Paleobotanical Principles
	2 nd BT202C	Paper-4A Theory	2	60 (IA=24 + ESE=36)	Fossil Plants-I	Fossil Plants-II	Principles of Organic Evolution-I	Principles of Organic Evolution-II
		Paper-4B Practicals	2	40 (IA=16 + ESE=24)	Based on Theory paper 3 & 4A			
2 nd	3 rd BT301C	Paper-5 Theory	4	100 (IA=40 + ESE=60)	Elementary Phytopathology	Angiosperm Morphology	Plant anatomy	Embryology
	3 rd BT302C	Paper-6A Theory	2	60 (IA=24 + ESE=36)	Taxonomy-I	Taxonomy-II	Monocot Families	Dicot Families
		Paper 6B Practicals	2	40 (IA=16 + ESE=24)	Based on theory paper 5 & 6A			
	4 th BT401C	Paper-7 Theory	4	100 (IA=40 + ESE=60)	Plant Ecology-I	Plant Ecology- II	Natural Resource Management & Sustainable Development	Phyto- geography
	4 th BT402C	Paper-8A Theory	2	60 (IA=24 + ESE=36)	Biophysics	Biochemistry-I	Biochemistry-II	Biochemistry- III
		Paper 8B Practicals	2	40 (IA=16 + ESE=24)	Based on theory paper 7 & 8A			
3 rd	5 th BT-501C	Paper-9 Theory	4	100 (IA=40 + ESE=60)	Cell biology-I	Cell Biology-II	Plant Physiology-I	Plant Physiology-II
	5 th BT502C	Paper-10A Theory	2	60 (IA=24 + ESE=36)	Genetics-I	Genetics-II	Genetics-III	Genetics-IV
		Paper 10B Practicals	2	40 (IA=16 + ESE=24)	Based on theory paper 9 & 10A			
	5 th BT503C	Paper-11 Theory	4	100 (IA=40 + ESE=60)	Molecular Biology-I	Molecular Biology-II	Molecular Biology-III	Plant Biotechnology- I
	5 th BT504C	Paper-12A Theory	2	60 (IA=24 + ESE=36)	Plant Biotechnology-II	Plant Biotechnology- III	Economic Botany-I	Economic Botany-II
		Paper 12B	2	40	Based on theory paper 11 & 12A			

		Practicals		(IA=16 + ESE=24)				
	6th BT601C	Paper-13 Theory	4	100 (IA=40 + ESE=60)	Plant Breeding	Biometry	Horticultural Practices-I	Horticultural Practices-II
	6th BT602C	Paper-14A Theory	2	60 (IA=24 + ESE=36)	Floriculture & Gardening-I	Floriculture & Gardening-II	Pharmacognosy	Ethnobotany
		Paper 14B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 13 & 14A</i>			
	6th BT603C	Paper-15 Theory	4	100 (IA=40 + ESE=60)	Industrial and Applied Microbiology-I	Industrial and Applied Microbiology-II	Algal Biotechnology	Applied Mycology
	6th BT604C	Paper-16A Theory	2	60 (IA=24 + ESE=36)	Palynology	Biodiversity and its Conservation-I	Biodiversity and its Conservation-II	Biodiversity and its Conservation-III
		Paper 16B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 15 & 16A</i>			
4th	7th BT701C	Paper-17 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	7th BT702C	Paper-18A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper 18B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 17 & 18A</i>			
	7th BT703C	Paper-19 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	7th BT704C	Paper-20A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-20B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 19 & 20A</i>			
	8th BT801C	Paper-21 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	8th BT802C	Paper-22A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-22B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 21 & 22A</i>			
	8th BT803C	Paper-23 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	8th BT804C	Paper-24A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-24B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 23 & 24A</i>			

***Has been added after 3rd year (6th semester)**

DETAILED COURSE CONTENT OF BOTANY MAJOR

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Microbiology-I

1. Significant contributions of Indian Plant Virologist: Pothur Sreenivasulu.
2. Carl Richard Woese's three domain system of classification.
3. **Microbial nutrition & Growth-** Nutritional requirements and nutritional types, Uptake of nutrients by microbial cells, Types of culture medium, Isolation of microbes in pure culture; **Microbial growth-** Phases of microbial growth, Measurement of microbial growth.
4. **Virus:** Nature of virus particles, Definition of Virion, Viroid, Prion & Satellite viruses; General structure of Virus particles - Forms of viral capsids (Helical & icosahedral), Types of nucleic acid in virus with examples, Structure of DNA virus (T4 phage), Lytic and lysogenic cycle, Structure and multiplication of RNA virus (TMV).
5. Transmission and translocation of Plant virus.
6. **Mycoplasma** – Definition & structure, Mycoplasmal plant diseases (examples).
7. **Actinomycetes** – Definition, general characters & Economic importance.

Unit-II: Microbiology-II

1. Significant contributions of Indian Plant Bacteriologist: P. Gunasekaran.
2. **Bacteria:** Morphological forms, Structure of bacterial cell.
3. **Bacterial chemotaxis** (definition & mechanism).
4. **Bacterial reproduction:** Asexual - Binary fission, Conidia, Budding, Cysts and Endospore (structure & formation).
5. Bacterial Plasmids (types) & Episome.
6. **Genetic recombination in bacteria** - Transformation, Transduction (Generalized & Specialized) and Conjugation (F-factor, $F^+ \times F^-$, Hfr $\times F^-$).
7. **Bacterial nutritional types** – Photosynthetic bacteria (definition and examples of Green sulphur bacteria, purple sulphur bacteria & non-sulphur bacteria); Chemosynthetic bacteria (definition and examples of Sulphur bacteria, Iron bacteria, Hydrogen bacteria & Nitrifying bacteria); Heterotrophic bacteria (Saprophytic & Parasitic).
8. **Economic importance of bacteria:** Beneficial role (role in Agriculture, Industry, Biological Control & Waste Water treatment) & Harmful effects (Food spoilage, Water pollution, Reduction of soil fertility & as Disease causing agent).

Unit-III: Phycology-I

1. Significant contributions of Indian Phycologists: Prof. M. O. P. Iyengar.
2. General characters of Algae: Occurrence, Range of thallus organization, Pigment types, Reserve food materials (RFM) in different groups, Algal Reproduction - Methods of Vegetative, Asexual and Sexual reproduction; Life cycle types.
3. Outline classification of Algae ((Lee, 1999) up to Class.
4. General characters of following algal classes – Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae & Rhodophyceae.
5. Economic importance of Algae.

Unit-IV: Phycology-II

1. Structure, reproduction and life-cycle of the following algal genera:
 - i. *Nostoc*
 - ii. *Oedogonium*
 - iii. *Chara*
 - iv. *Vaucheria*
 - v. *Ectocarpus*
 - vi. *Polysiphonia*
2. Diatoms – Cell structure, reproduction & economic importance.

Botany (Major)

SEMESTER-I

Paper- 2A (Theory)

BT-102C- Mycology, Lichen, Myxomycetes & Mycorrhiza

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Mycology-I

1. Significant contributions of Prof. T. S. Sadasivan.
2. **General characters of Fungi** – (i) Vegetative structure (Unicellular and mycelial forms); (ii) Hyphal forms – Plectenchyma, Sclerotia, Rhizomorphs, Haustoria, Appresoria, Stroma & Hyphal trap; (iii) Fungal cell wall – Composition; (iv) Fungal mode of nutrition.
3. **Fungal reproduction** – (i) Holocarpic & Eucarpic fungus; (ii) Vegetative reproduction – Fragmentation, Fission & Budding; (iii) Asexual reproduction - Different asexual spore forms (Zoospores, Conidia, Oidia, Chlamydospores & Sporangiospores; (iv) Sexual reproduction - Stages of sexual reproduction (Plasmogamy, Karyogamy & Meiosis), Different methods of Plasmogamy (Gametic copulation, Gametangial contact, Gametangial copulation, Somatogamy & Spermatization); (v) Different types of sexual spores – Ascospores, Basidiospores, Zygosporangia & Oospores.

Unit-II: Mycology-II

1. **Classification of Fungi** (Ainsworth, 1973) up to sub-division.
2. **Important characteristics of important fungal groups** –
 - i. Mastigomycotina.
 - ii. Zygomycotina.
 - iii. Ascomycotina (including types of ascocarps and development of ascus and ascospores),
 - iv. Basidiomycotina (including types and development of basidia and basidiospores).
 - v. Deuteromycotina (including types of spores).

Unit-III: Mycology-III

1. Structure, reproduction & life cycle of following fungal genera –
 - i) *Rhizopus*
 - ii) *Saccharomyces*
 - iii) *Ascobolous*
 - iv) *Penicillium*
 - v) *Agaricus*
 - vi) *Fusarium*.

Unit-IV: Lichen, Myxomycetes & Mycorrhiza

1. **Lichens:** General characters - morphological types, internal structure & reproduction; Ecological and economic importance of lichens.
2. **Myxomycetes:** General characters, Types of Plasmodia, Types of Fruiting bodies.
3. **Mycorrhiza:** Types of Mycorrhizal association, Role of Mycorrhizal fungi in agriculture and Forestry.

Botany (Major)
SEMESTER-I
Paper-2B (Practical)
BT-102C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No.	Practical	Marks
1.	Workout on Microbiology	05
2.	Workout on Algae	06
3	Workout on Fungi	06
4.	Identification with reasons (2 x 1½marks)	03
5.	Laboratory Note book	02
6.	Viva voce	02
TOTAL		24

CONTENTS

1. Use of Simple and Compound microscope.
2. **Work out on Microbiology:**
 - (a) Gram staining of bacterial population from curd.
 - (b) Demonstration of Sterilization process.
3. Work out of the following algal genera with reproductive structures (Free hand drawing only): *Nostoc* sp., *Oedogonium* sp., *Chara* sp., *Ectocarpus* sp., *Polysiphonia* sp.
4. **Work out of the following Fungi** with reproductive structures (Free hand drawing): *Rhizopus* sp., *Penicillium* sp., *Ascobolus* sp., *Agaricus* sp., *Polyporus* sp.
5. **Identifications:**
 - a) **Permanent slides of Algae:** *Nostoc*, *Volvox* colony, *Oedogonium* dwarf male, *Ectocarpus* with plurilocular sporangia, *Polysiphonia* – cystocarp & tetrasporophyte.
 - b) **Permanent slides of Fungi:** Zygosporangium of *Rhizopus*, Conidiophore of *Penicillium*, T.S. of gills of *Agaricus*, T.S. of basidiocarp of *Polyporus*, Conidia of *Fusarium*.
 - c) **Macro specimen** - Fruitbody of *Agaricus*, *Polyporus*
6. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
7. **Viva voce:** Questions based on theory and practical syllabus of 1st semester.

Botany (Major)
SEMESTER-II

Paper-3 (Theory)

BT-201C- Bryophyta, Pteridophyta, Gymnosperms & Basic Paleobotany

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Bryophyta

1. Significant contributions of Indian Bryologist: Prof. Shiv Ram Kashyap.
2. General characters of Bryophytes.
3. Bryophyta - Adaptations to land habit.
4. Outline Classification - (Crandall-Stotler and Stotler, 2000) up to class.
5. Distinctive features of three major groups – Liverworts (Phylum: Marchantiophyta), Hornworts (Phylum: Anthocerotophyta), and Mosses (Phylum: Bryophyta).
6. Importance of Bryophyta – Ecological significance & economic importance of bryophytes.
7. Gametophyte structure, Reproduction, Development and Structure of sporophyte, Spore dispersal of *Riccia*, *Marchantia*, *Anthoceros*, *Funaria*.

Unit-II: Pteridophyta

1. General characters of Pteridophytes.
2. Life cycle pattern (Homosporous and Heterosporous).
3. Apogamy & Apospory.
4. Outline classification (Sporne, 1975) up to Order with example.
5. Important characters of Psilophytopsida, Psilotopsida, Lycopsidea, Sphenopsida, and Pteropsida.
6. Morphology, anatomy and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris*.

Unit-III: Gymnosperms

1. General characters of Progymnosperms, Classification of Progymnosperms, Vegetative and reproductive structures of *Archaeopteris*.
2. General characters of Gymnosperms.
3. Outline classification (Sporne, 1965) up to Order with example.
4. Important characters of Cycadopsida, Coniferopsida, and Gnetopsida.
5. Economic importance with reference to Wood, Resins, Essential oils, and Drugs.
6. Distribution, morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo*, and *Gnetum*.

Unit-IV: Basic Paleobotanical Principles

1. Significant contributions of Indian Paleobotanist: Dr. Birbal Sahani.
2. Definition of fossil, Conditions required for fossilisation, fossilisation process.
3. Types of fossil (Body fossil - Micro- and Megafossils, Trace fossil, Chemical fossil, Index fossil).
4. Modes of preservation (after Schopf, 1975).
5. Concept of reconstruction and formed genus.
6. Geological time scale with dominant plant groups through ages.
7. Techniques for studying plant fossils.
8. Principles of radiometric fossil dating (brief idea).
9. Importance of fossil study.

Botany (Major)
SEMESTER-II
Paper- 4A (Theory)
BT-202C- Fossil Plants & Principles of Organic Evolution

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Fossil Plants - I

1. Study of the following fossil plants:
 - i. *Rhynia*
 - ii. *Lepidodendron*
 - iii. *Calamites*
 - iv. Paleozoic seed fern - *Lyginopteris*
 - v. Mesozoic seed fern - *Caytonia*

Unit-II: Fossil Plants - II

1. Study of the following fossil plants:
 - i. *Willimsonia*
 - ii. *Pentoxylon*
 - iii. *Cordaitea*
2. Indian Gondwana flora system - Three fold division with major megafossil assemblages.

Unit-III: Principles of Organic Evolution-I

1. Origin of life (Oparin-Haldane concept, Urey-Miller experiment, RNA world hypothesis, Protein first model, Origin of proto cells – Sydney Fox's experiment, Proteinoids, Microspheres & Coacervates).
2. Species Concept – Morphological, Ecological, Evolutionary & Biological species concept.
3. Reproductive isolation - Definition and types (pre zygotic & post zygotic isolating mechanisms).
4. Modes of speciation (Allopatric, Peripatric, Parapatric, & Sympatric).
5. Phyletic gradualism, Punctuated equilibrium and Stasis.

Unit-IV: Principles of Organic Evolution-II

1. Natural selection - Definition and types (Directional, Stabilizing, Disruptive).
2. Darwinism and its limitations.
3. Neo Darwinism (only brief idea).
4. Sexual selection and Group selection (definition).
5. Coevolution – Definition and example.
6. Macro and Micro evolution (definition).
7. Adaptive radiation and convergence.

Botany (Major)
SEMESTER-II
Paper-4B (Practical)
BT-202C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No.	Practical	Marks
1.	Workout on Pteridophyta	06
2.	Workout on Gymnosperm	05
3	Identification with reasons (4 x 2 marks)	08
4.	Laboratory Note book	02
5.	Viva voce	03
TOTAL		24

1. Work out on:

(a) Pteridophytes: Workout on reproductive structures of the following Pteridophytes: *Lycopodium* sp., *Selaginella* sp., *Equisetum* sp., *Pteris* sp.

(b) Gymnosperms: Leaflet of *Cycas* sp, *Pinus* sp., Microsporophyll of *Cycas* sp.

2. Identification:

(a) Morphological study of the Bryophyte genera: *Riccia*, *Marchantia*, *Anthoceros*, and *Funaria*.

(b) Study of Bryophytes from permanent slides – *Riccia* (V.S. of thallus), *Marchantia* (L.S. of: Gemma cup, antheridiophore, archegoniophore, sporophyte), *Anthoceros* (L.S. of sporophyte), *Funaria* (L.S. capsule).

(c) Study of macroscopic structures of Gymnosperm: *Cycas* microsporophylls, *Cycas* megasporophyll, *Pinus* male cone, *Pinus* female cone, *Gnetum* male cone, *Gnetum* female cone.

(d) Study of Gymnosperms from permanent slides – L.S. of *Cycas* ovule, L.S. of *Pinus* male cone, L.S. of *Pinus* female cone, Pollen grains of *Pinus*, L.S. of *Gnetum* male cone, L.S. of *Gnetum* female cone/ovule.

(e) Study from permanent slides / macroscopic fossil specimen.

3. Laboratory Records: Student must get the laboratory note books duly signed by the respective teacher during practical classes.

4. Viva voce: Questions based on theory and practical syllabus of 2nd semester.

Botany (Major)

SEMESTER-III

Paper- 5 (Theory)

BT-301C- Phytopathology, Angiosperm Morphology, Plant Anatomy & Embryology

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Elementary Phytopathology

1. Significant contributions of Indian Plant Pathologist: K.C Mehta and B.B Mundkur.
2. **Terms and concepts** - Infection disease, Non-infection disease, Host (types – Primary, Alternate & Collateral), Pathogen (types), Pathogenecity, Pathogenesis, Necrotroph, Biotroph, Koch's postulates, Inoculum (primary & secondary), Inoculum potential, Causal complex, Disease triangle, Disease cycle, Endemic disease, Epidemic disease, Sporadic disease, Resistance (horizontal & vertical), Hypersensitivity & Klenducity.
3. **Types of symptoms** (Necrotic, Atrophic, Hypertrophic).
4. **Control measures of plant disease** – Physical, Chemical, Biological and Cultural methods.
5. **Specific plant diseases:** Late blight of potato, Brown spot of rice, Black stem rust of wheat, Stem rot of jute, Red rot of sugarcane, Tikka disease of ground nut.

Unit-II: Angiosperm Morphology

1. **Root** – Types and modifications.
2. **Leaf** – Types, Phyllotaxy, Stipule types, Venation types.
3. **Inflorescence** – Types (Racemose, Cymose, Mixed & Special).
4. **Flower** - Types of flower, complete general morphology of flower, types of aestivation, Placentation types.
5. **Fruit** - Types of fruit.
6. **Seed** - Structures of typical seeds (endospermic and non-endospermic).
7. Fruit and seed dispersal mechanisms.

Unit-III: Plant Anatomy

1. Composition and gross structure of Plant Cell Wall.
2. Meristematic tissues: General characters, Classification.
3. Permanent tissue: Parenchyma (general character), Collenchyma (general character and classification), Sclerenchyma (general character and types of sclerides).
4. Components of Xylem and Phloem.
5. Epidermal tissue system - Cuticle, Epicuticular waxes (including functions), Trichomes (uni-and multicellular, glandular and nonglandular), Types of stomata.
6. Vascular tissue system - Types of vascular bundles.
7. Stele types and evolution.
8. Hydathodes, Lithocysts and Laticifers.
9. General anatomical characters of monocot stem and root, Dicot stem and root, Dorsiventral and isobilateral leaf.
10. Normal secondary growth in dicot stem and root.

Unit-IV: Embryology

1. Structure of Microsporangium (anther).
2. Microsporogenesis & formation of male gametophyte.
3. Megasporogenesis & development of female gametophyte (types – Monosporic, Bisporic & Tetrasporic).
4. Ovule – Structure & types.
5. Process of double fertilization.
6. Embryo development (Dicot & Monocot type).
7. Endosperm development – Nuclear, Cellular & Hellobial types.
8. Polyembryoni (definition and types) and Apomixis (types).

Botany (Major)
SEMESTER-III
Paper- 6A (Theory)
BT-302C- Taxonomy

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Taxonomy-I

1. Significant contributions of plant taxonomist: H. Santapau and Prof. Gurucharan Singh.
2. Definition of Taxonomy and Systematics.
3. Principles of taxonomy, Aims of taxonomy, Phases of taxonomy.
4. Herbarium techniques and importance of herbaria.
5. Botanical gardens and their importance.
6. Important Herbaria and Botanical gardens of the world and India.
7. Nomenclature – Binomial nomenclature & its importance.

Unit-II: Taxonomy-II

1. Classification – Definition & types with examples.
2. Artificial Classification – Linnaeus system of classification.
3. Natural Classification - Bentham and Hooker's classification up to series and its merits and demerits.
4. Phylogenetic Classification - Hutchinson's classification with merits and demerits.
5. Taxonomic Key – Dichotomous key (Indented & Bracketed keys).
6. ICN – Principles.

Unit-III: Monocot families:

1. Study of Angiospermic families (diagnostic characters, general characters and economic importance):
 - i. Poaceae
 - ii. Liliaceae
 - iii. Orchidaceae
 - iv. Arecaceae
 - v. Musaceae
 - vi. Cannaceae
 - vii. Zingiberaceae

Unit-IV: Dicot families:

1. Study of Angiospermic families (diagnostic characters, general characters and economic importance):
 - i. Magnoliaceae
 - ii. Malvaceae
 - iii. Cucurbitaceae
 - iv. Solanaceae
 - v. Lamiaceae
 - vi. Apocynaceae
 - vii. Verbenaceae
 - viii. Rubiaceae
 - ix. Leguminosae
 - x. Brassicaceae
 - xi. Asteraceae

Botany (Major)
SEMESTER-III
Paper-6B (Practical)
BT-302C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No.	Practical	Marks
1.	Workout on Angiospermic plant	07
2.	Workout on Anatomy	05
3.	Identification with reasons (2 x 1½ marks)	03
4.	Spot identification of plants (2 x 1marks)	02
5.	Submission of Herbarium sheets	1 ½
6.	Submission of Field Note Book	1 ½
7.	Laboratory Note book	02
8.	Viva voce	02
TOTAL		24

1. **Workout on Angiospermic plants:** Flower dissection, diagram of plant parts, floral diagram, description of plant, floral formula, identification of the family from the families included in the theory syllabus.
2. **Work out on Plant Anatomy:** Study of Primary structures by preparing temporary slides of the following: **Monocot stem:** T. S. of *Canna* scape / T. S. of Maize stem, **Dicot stem:** T. S. of *Cucurbita* stem / T. S. of Sunflower stem, **Monocot root:** T. S. of Arum root / T. S. of Orchid root, **Dicot root:** T. S. of *Pisum* root, **Dorsiventral leaf:** T. S. of Mango leaf, Isobilateral leaf: T. S. of Bamboo leaf / T. S. of *Phoenix* leaf.
3. **Identification:**
 - i. **Inflorescence types:** Study from fresh or preserved specimens.
 - ii. **Flowers types:** Study of different types of flowers from fresh or preserved specimens- Achlamydeous, Monochlamydeous, Dichlamydeous, Actinomorphic, Zygomorphic flowers.
 - iii. **Corolla types:** Study of different types of corolla from fresh or preserved specimens- Cruciform, Rosaceous, Papilionaceous, Tubular, Campanulate, Hypocrateriform, Infundibuliform, and Bilabiate.
 - iv. **Types of stamens:** Study of different types of stamens from fresh or preserved specimens - Monadelphous, Diadelphous, Polyadelphous, Syngenesious, Synandrous, Epipetalous, Gynandrous.
 - v. **Types of placentation:** Study of different types of placentations.
 - vi. **Types of fruits:** Study from fresh or preserved specimens.
 - vii. **Minor anatomy:** Stomata types, Cystolith, Raphides, Starch grains, Laticiferous ducts.
 - viii. **Pathological specimens:** Name of the disease, Name of Pathogen, Identifying characters of - Brown spot of Rice, Late blight of Potato, Stem rot of Jute, Red rot of Sugarcane.
4. **Spot identification:** Scientific names of common wild plants from the families included in theory syllabus.
5. **Submission of Herbarium sheets:** At least **20 herbarium sheets** must be submitted.
6. **Field Note book:** Students are required to go for **at least one** field study tour.
7. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
8. **Viva voce:** Questions based on theory and practical syllabus of 3rd semester.

Botany (Major)

SEMESTER-IV

Paper-7 (Theory)

BT-401C- Plant Ecology, Natural Resource Management & Phytogeography

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Plant Ecology-I

1. Significant contributions of Prof. Ramdeo Misra.
2. Basic ecological concepts – (i) Trophic levels, (ii) Food chain & Food web, (iii) Ecological pyramids – Pyramids of Number, Biomass & Energy, (iv) Energy flow model.
3. Concept of Productivity – Primary & Secondary productivity.
4. Ecological Niche- (i) Definition of Niche, (ii) Types of Niche - Habitat, Trophic and Multidimensional niche, (iii) Fundamental and realized niche, (iv) Niche overlapping and concept of competitive exclusion, (v) resource partitioning, (vi) Ecological equivalent & Guild (definition).
5. Ecology of species- (i) Reproductive strategy (r and k selection), (ii) Interaction between species (competition, consumption, cooperation)
6. Population ecology- (i) Definition of population, (ii) population growth forms (J-shaped and S-shaped), (iii) Carrying capacity & Biotic potential (definition).

Unit-II: Plant Ecology-II

1. Community ecology- (i) Definition of Biotic Community, (ii) Ecological Succession – Types of Succession (Primary and secondary, Allogenic & Autogenic, Autotrophic and Heterotrophic), Stages in successional process; Models of succession – Facilitation, Tolerance and Inhibition models, Concept of climax – (Characters of climatic vegetation, Monoclimax & Polyclimax theory).
2. Hydrosere and Xerosere.
3. Ecological adaptations of Hydrophytes, Xerophytes & Halophytes.
4. Ecotone and edge effect (only definition)
5. Soil - Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile, Types of soil water.
6. Biogeochemical cycles – C, N, and P cycle.

Unit-III: Natural Resource Management & Sustainable Development

1. Natural resource:

- i. Definition and types of Natural resource.
- ii. Sources of energy - Conventional & non-conventional (Solar, Wind, Hydel, Geothermal, Tidal and Nuclear energy); Basic concept of energy plantation.
- iii. Soil - degradation and management strategies and restoration of degraded lands.
- iv. Wetlands - major threats and management strategies.
- v. Forest - Causes of forest depletion and management strategies.
- vi. Wasteland reclamation.

2. Sustainable development:

- i. Definition & concept of Sustainable Development.
- ii. Goals of sustainable development.
- iii. Organic farming (principle, advantages, & disadvantages).
- iv. Bio fertilizers (definition, examples & importance).
- v. Biofuels (concept, example, sources & importance).

Unit-IV: Phytogeography

1. Principles of Phytogeography.
2. Concept of Continental drift & Theory of tolerance.
3. Theory of Island Biogeography.
4. Endemism - Definition, types, theories of endemism & factors responsible for endemism.
5. Phytogeographical regions of India (D. Chatterjee, 1962).
6. Vegetation of Eastern Himalaya, Western Himalaya & Sunderban.
7. Vegetation of Tripura.
8. Brief concept of major terrestrial Biomes (climatic and geographical conditions & major plant types) – Tropical Rain Forest, Tropical Savanna, Temperate Deciduous Forest, Grassland & Tundra.

Botany (Major)

SEMESTER-IV

Paper-8A (Theory)

BT-402C- Biophysics & Biochemistry

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Biophysics

1. Types of chemical bonds.
2. Structure and properties of water.
3. Solution – Percentage, Molar, & Normal solutions (definitions).
4. Colloids – Definition, Types (Sol, Gel, Emulsion, Soliosol, Aerosol & Foam) and properties of colloids.
5. Acid, Base, pH, pKa, Buffer system & its types, Isoelectric point, Zwitterion.
6. Diffusion (definition) & Fick's law of diffusion.
7. Osmosis and Osmotic pressure (definition & van't Hoff Laws).
8. Viscosity (definitions) and Factors for viscosity of liquids (Density, Temperature, Solute concentration & Size and shape of solute particles).
9. Surface tension (definition).

Unit-II: Biochemistry –I (Fundamental & Carbohydrate Biochemistry)

1. Bioenergetics- Free Energy (definition) & standard Free Energy change (ΔG°), Endergonic and Exergonic reaction.
2. Coupled reaction, ATP structure and importance.
3. Importance of NADH, NADPH & FADH₂.
4. Carbohydrates- Classification (monosaccharides, disaccharides, oligosaccharides and polysaccharides).
5. L and D stereoisomerism, Epimers & Anomers (definition), Reducing & Non-reducing sugars.
6. Modification of monosaccharides – Amino sugar, Uronic acid.
7. Chemical nature of important polysaccharides – Starch, Glycogen, Cellulose & Chitin.
8. Glycolipids & Glycoproteins (O-linked & N-linked).
9. Functions of Carbohydrates.

Unit-III: Biochemistry-II (Lipid Biochemistry)

1. Types of fatty acids (saturated and unsaturated); cis-double bond & trans-double bond in unsaturated fatty acids; PUFA & MUFA.
2. Properties of fatty acids – Esterification, Hydrogenation, Halogenation.
3. Types of lipids - Simple, compound (phospholipids, glycolipids & lipoproteins) and derived lipids.
4. Properties of fats – Emulsification, Saponification, Rancidity.
5. Characterizing fats – Saponification number, Iodine number.
6. Cholesterol – Chemical nature and function (in plants).
7. Micelle, Lipid bilayer & Liposome (definition / brief idea).
8. Functions of Lipids.

Unit-IV: Biochemistry-III (Protein Biochemistry & Enzymes)

1. **Proteins-** (i) Types of amino acid & Essential amino acid (ii) Properties of peptide bond, (iii) Levels of protein structure - Primary, Secondary (α helix, β -sheet & β -turn), Tertiary and Quaternary.
2. Classification of Proteins (Simple, Compound & Derived) & Functions of proteins.
3. **Enzymes:** (i) Structure (holoenzyme, apoenzyme, cofactor, coenzyme and prosthetic group) (ii) Active site – Properties, (iii) Classification of enzymes, (iv) Mechanism of enzyme action (activation energy, lock and key hypothesis, induced - fit theory), (v) Effect of substrate concentration and Michaelis - Menten equation, Concept of K_M value, (vi) Effect of temperature and pH, (vii) Enzyme inhibition- competitive, uncompetitive and noncompetitive (only definition), (viii) Allosteric enzymes – Definition and properties, (ix) Isozymes, (x) Ribozymes (definition).

Botany (Major)
SEMESTER-IV
Paper-8B (Practical)
BT-402C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No	Practicals	Marks
1.	Study of Ecological anatomy	05
2.	Study on properties of soil	04
3.	Preparation of map of Phytogeographical regions of India with plant name.	04
4.	Detection of Biochemical compound from unknown sample.	05
5.	Laboratory Note book	03
6.	Viva voce	03
TOTAL		24

- 1. Study of Ecological anatomy:** Hydrophytes (*Hydrilla* stem, *Nymphaea* petiole), Xerophytes (*Nerium* leaf).
- 2. Study on physical properties of soil:**
 - (a) Determination of pH of different types of soil by pH paper method.
 - (b) Determination of water holding capacity of soil samples.
 - (c) Determination of porosity of different soil samples.
- 3.** Preparation of map of Phytogeographical regions of India (D. Chatterjee, 1962) with plant name.
- 4. Biochemical detection:**
 - (a) **Detection of carbohydrates:** Glucose, Fructose, Sucrose & Starch.
 - (b) **Detection of organic acids:** Oxalic acid, Tartaric acid, Citric acid.
 - (c) **Detection of Proteins**
- 5. Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
- 6. Viva voce:** Questions based on theory and practical syllabus of 4th semester.

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Cell Biology-I

1. Origin of Eukaryotic cell – endosymbiotic theory.
2. Ultra structure of cell wall.
3. Composition, structure and fluidity of plasma membrane.
4. Transport across plasma membrane.
5. Structure and function of Mitochondria and Chloroplast & their semiautonomous nature.
6. Structure and functions of Endoplasmic reticulum, Golgi body, Ribosome, Peroxisome, and Lysosome.

Unit-I: Cell Biology-II

1. Significant contributions of: Prof. Arun Kr. Sharma.
2. Structure of Nucleus and Nucleolus.
3. Structure of chromatin (Nucleosome concept and different levels of chromatin organization), Chromosome morphology, Properties of Centromere & Telomere.
4. Cell division- Cell cycle (different phases & their significance), Stages of Mitosis and Meiosis.
5. C-value, C-value paradox, Relation between chromosome number and C-value through different stages of Mitosis and meiosis.
6. Regulations of cell cycle – Cell cycle check points, Role of MPF in cell cycle regulation.

Unit-III: Plant Physiology-I

1. Plant water relationship - Water Potential and its components, Pathway of water movement (symplast & apoplast), Ascent of sap–cohesion-tension theory.
2. Transpiration – Types of transpiration, mechanism of stomatal movement, antitranspirants.
3. Macro and Micronutrients – Mechanism of mineral absorption; Physiological roles and deficiency symptoms of macro nutrients.
4. Photosynthetic pigments, Structure of PSI and PSII, Photosynthetic electron transport, Photophosphorylation, Red drop, Emmerson effect.
5. C3 cycle, C4 cycle, CAM.
6. Photorespiration.

Unit-IV: Plant Physiology-II

1. Glycolysis, Oxidative decarboxylation, TCA cycle, Mitochondrial electron transport.
2. Pentose Phosphate pathway.
3. Nitrate assimilation, Biological N fixation (nodule formation, role of Nitrogenase and leg haemoglobin), function of *nif* and *nod* genes.
4. Plant hormones - Chemical nature, source and physiological roles of Auxin, Gibberellins, Cytokinin, Function of Absciscic acid, Ethylene.
5. Photoperiodism- Photoperiodic classification of plants, Phytochrome- Chemical nature, mode of action, role in flowering; Floral induction – role of Florigen.
6. Seed dormancy (Types, causes, methods of breaking seed dormancy).

Botany (Major)
SEMESTER-V
Paper-10A (Theory)
BT-502C- Genetics

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Genetics-I

1. **Mendelian genetics** - Principles of segregation and independent assortment, Concept of Dominance, Incomplete dominance, Codominance, Multiple allele, Penetrance, Expressivity, Pleiotropism, Phenocopy effect and Atavism.
2. **Determining allelism of mutants** – Complementation test; Definition of Cistron, Muton & Recon; Concept of pseudoallele; Fine structure of gene – Structure of phage rII locus.
3. **Gene interactions** with modified dihybrid ratios (12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1).

Unit-II: Genetics-II

1. **Cytoplasmic inheritance** - Features of cytoplasmic inheritance, Plastid inheritance- leaf colour in mirabilis, Mitochondrial inheritance - Poky & Petite mutation, Maternal effect- shell coiling in snail.
4. **Linkage & Crossing over** - Definitions of complete, incomplete, coupling phase and repulsion phase linkage, linkage group, Crossing over – definition and cytological basis (McClintock Experiment).
5. **Recombination** – Basic concept, Recombination frequency, Two point & Three point test cross, Gene mapping from three point test cross data, coefficient of correlation, interference.

Unit-III: Genetics-III

1. **Chromosomal aberration** - Numerical changes (aneuploidy and euploidy), Polyploidy types; Structural changes - Definition and types of Deletion, Duplication, Inversion and Translocation; Meiotic behaviour of inversion and translocation heterozygotes; Position Effect.
2. **Sex determination** – Mechanism of sex determination in Human and Drosophila.
3. **Sex linkage** – Sex linked inheritance, Dosage compensation & Lyon's hypothesis, Sex limited & Sex influenced traits, Problems on Sex linkage (Haemophilia & Colour blindness).

Unit-IV: Genetics-IV

1. **Population genetics** – Concept of Gene pool, Allele frequency & Genotype frequency, Hardy-Weinberg law, Conditions for HW equilibrium, Numerical problems based on HW equation.
2. **Factors affecting changes in gene frequency** – Migration, Mutation, Selection & Genetic drift (definition and effects on gene frequency).
3. **Quantitative inheritance** - Characters of quantitative traits, Heritability – Narrow sense & Broad sense Heritability; Polygenic inheritance – Regulation of kernel colour in wheat.

Botany (Major)
SEMESTER-V
Paper-10B (Practical)
BT-502C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No	Practicals	Marks
1.	Work out on Mitotic stages	05
2.	Identification with reasons (2 x 1 ½)	03
3.	Testing goodness of fit of modified di-hybrid ratios (12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1)	04
4.	Plant Physiology experiment	08
5.	Laboratory Note book	02
5.	Viva voce	02
TOTAL		24

- 1. Work out on Mitotic study:** Temporary preparation of mitotic stages from the root tips of *Allium cepa*.
- 2. Biometry:** Determination of goodness of fit (chi square test) of modified di-hybrid ratios (12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1)
- 3. Identification:** Study of different stages of Mitosis and Meiosis (Normal and /or Abnormal) from permanent slides.
- 4. Plant Physiological experiments:**
 - Comparison of imbibitions of water by Starchy, Proteinaceous and Fatty seeds.
 - Comparison of water loss in dorsiventral leaf by Cobalt Chloride method.
 - Relationship between transpiration and evaporation.
 - Separation of Chlorophyll pigments by paper chromatography.
 - Determination of released oxygen during photosynthesis.
- 5. Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
- 6. Viva voce:** Questions based on theory (paper 9 & 10A) and practical (paper 10B) syllabus of fifth semester.

Botany (Major)
SEMESTER-V
Paper-11 (Theory)

BT-503C- Molecular Biology & Plant Biotechnology-I

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Molecular Biology-I

1. Significant contributions of: Prof. H. G. Khorana.
2. DNA structure (characters of double helix), types of DNA (A, B and Z forms).
3. Characters of mRNA, rRNA and tRNA (including clover leaf structure of tRNA).
4. Gene structure in prokaryotes and eukaryotes, structure of prokaryotic and eukaryotic mRNA (concept of monocistronic & polycistronic mRNA).
5. Transposable genetic elements – Bacterial IS element, Transposons and retrotransposons (only definition).
6. Organelle DNA - Mitochondria and Chloroplast DNA (properties and structure).

Unit-II: Molecular Biology-II

1. DNA replication (general properties – bidirectional, semi conservative, semi discontinuous, concept of replicon), DNA replication mechanism in *E. coli* (role of different enzymes and proteins, synthesis of leading and lagging strands).
2. Transcription- initiation, elongation and termination in *E. coli*.
3. Genetic code - Properties, wobble concept.
4. Translation - Amino-acylation of tRNA, initiation, elongation (peptidyltransferase reaction), and termination in *E. coli*.

Unit-III: Molecular Biology-III

1. Regulation of Gene expression in Prokaryotes - Operon model (general concept), lac-operon with its positive and negative control, arabinose operon, trp-operon and attenuation.
2. Gene mutation - Base substitution and Frame shift mutation, Effect of UV rays, Base analogues, Alkylating agents, Intercalating agents and Deaminating agents.
3. DNA repair system – Photoreactivation, Mismatch repair, Excision repair.

Unit-IV: Plant Biotechnology-I

1. Totipotency and concept of Plant Tissue Culture, Function and organization of Plant tissue culture laboratory.
2. Composition of plant tissue culture medium.
3. Sterilization technique.
4. Different growth regulators used in plant tissue culture and their role.
5. Micropropagation – process (stages) and importance.
6. Plant Regeneration - Concept of organogenesis and embryogenesis (direct and indirect).
7. Callus culture and its application.
8. Cell suspension culture.

Botany (Major)

SEMESTER-V

Paper-12A (Theory)

BT-504C- Plant Biotechnology-I & II and Economic Botany

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Plant Biotechnology-II

1. Definition of 'Androgenesis' and 'Androgenic Haploids'; Haploid production through anther and pollen culture with advantages and disadvantages; Production of diploids from haploids; Application of Haploids.
2. Embryo culture and its application.
3. Protoplast culture technique and somatic hybrid production; Application of Protoplast culture.
4. Synthetic seed (definition and types).

Unit-II: Plant Biotechnology-III

1. Vector system: Cloning Vectors– Criteria for good vector, Plasmid vectors – pBR322, pUC19, λ -phage vector (Insertional & Replacement), Cosmid vector, Phagemid vector, BAC & YAC.
2. Enzymes in DNA cloning – Restriction endonuclease (Type I, II, III).
3. PCR – Basic principle, steps & application, principle of RTPCR.
4. Construction of genomic library & Construction of cDNA library.
5. Screening of recombinant clones: Blue-White screening & Reporter Gene Assay (GFP).
6. Blotting techniques: Principles of Northern, Southern and Western Blotting.
7. Production of transgenic plant (Physical delivery and *Agrobacterium* mediated gene transfer).
8. Molecular DNA markers (RAPD, RFLP).

Unit-III: Economic Botany-I

1. Concept of Centres of Origin and their importance with reference to Vavilov's work - (Name of centers, countries included, & examples of crops originated).
2. Crop domestication – Definition of Domestication, Changes during domestication, Loss of genetic diversity.
3. Process of evolution of new crops/ varieties.
4. Importance of germplasm diversity.
5. **Scientific name, family, part used, and uses of following plants:** Cereal– Rice, Wheat; Pulses– Gram, Moong and Lens; Beverages – Tea and Coffee; Fruits – Mango, Citrus and Papaya; Drug yielding – *Cinchona*, *Rauwolfia*, *Digitalis*, *Papaver*, *Andrographis*; Spices – Ginger, Cumin and Clove; Oil yielding – Mustard, Groundnut, Coconut and Linseed; Vegetables – Potato, Radish and Cabbage; Fibre yielding– Cotton and Jute; Timber yielding – Teak and Sal; Sugar yielding– Sugarcane and Sugar beet; **Others** – Bamboo & Cane.

Unit-IV: Economic Botany-II

1. Rice cultivation (Rice growing seasons in India, Soil types for rice cultivation, Conventional method and SRI method with advantages and disadvantages).
2. Fibers - Classification based on the origin of fibres, Jute cultivation and processing.
3. Tea cultivation and processing (orthodox and CTC).
4. Rubber cultivation and processing.
5. Morphology and processing of sugarcane and products and by products of sugarcane industry.
6. Paper and Pulp Industry: Major raw materials for paper pulp, Manufacture of pulp and paper production.

Botany (Major)
SEMESTER-V
Paper-12B (Practical)
BT-504C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No	Practicals	Marks
1.	Demonstration on aseptic explant preparation (from shoot tip and nodes) and aseptic inoculation of explants.	07
2.	Study of economically important plants (Scientific name, Family, Economically important part, and Uses) as per theory syllabus (2 x 3 marks)	06
3.	Comparative microscopic study of starch grains from different sources with staining – Pea seed, Banana fruit, Sweet potato tuber, Maize grain, Potato tuber	05
4.	Submission of economically important plant	02
5.	Laboratory Note book	02
5.	<i>Viva voce</i>	02
TOTAL		24

1. Demonstration on functioning of Autoclave, pH meter, Laminar Air Flow.
2. Demonstration on sterilization technique.
3. Demonstration of aseptic inoculation technique.
4. Study of economically important plants (Scientific name, Family, Economically important part, and Uses)
5. Comparative microscopic examination of different types of starch grains (Type – simple / compound, Shape, Position of hilum – concentric / excentric) from different sources – Pea seed, Banana fruit, Sweet potato tuber, Maize grain, Potato tuber.
6. Submission of economically important plants (herbarium/ specimen) [at least six].
7. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
8. **Viva voce:** Questions based on theory (paper 11 & 12A) and practical (paper 12B) syllabus of fifth semester.

Botany (Major)
SEMESTER-VI
Paper-13 (Theory)

BT-601C- Plant Breeding, Biometry & Horticultural Practices

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Plant Breeding

1. Aims of plant breeding.
2. Breeding methods: Plant introduction – Process, merits and demerits, Acclimatization.
3. Plant domestication – Changes in plants under domestication and loss of genetic diversity.
4. Mass selection, Pureline selection, Clonal selection.
5. Hybridization (different steps) & Production of synthetic variety.
6. Heterosis (definition, genetic and biochemical basis, importance in plant breeding) & Inbreeding depression.
7. Polyploidy – Types, Artificial induction of polyploidy, Effects of polyploidy on crop species, Role of polyploidy in plant breeding.

Unit-II: Biometry

1. Presentation of statistical data – Concept of variable and attribute, Primary and Secondary data, Population and Sample.
2. Frequency and frequency distribution.
3. Graphical presentation of data – Bar diagram & Histogram, Pie chart.
4. Measures of central tendency (Arithmetic mean, Median, Mode).
5. Measures of dispersion (Mean deviation, Standard deviation, Standard error).
6. Test of significance – Null hypothesis and Alternate hypothesis, Degree of Freedom, Level of Significance, Student t-test, chi square test for Goodness of fit.
7. Simple Correlation and Coefficient of correlation (r).
8. Definition of probability, Addition and Multiplication rule.

Unit-III: Horticultural Practices-I

1. Green house – General construction and types.
2. Soilless plant culture - water culture (hydroponic culture) and substrate culture, Nutrient Film Technique (NFT).
3. Seed propagation – Seed structure and types, seed formation, germination types of seed, advantage & disadvantage of seed propagation, Direct and indirect seeding – advantages and disadvantages.
4. Seed production and certification process, Nuclear seed, Breeder seed, Foundation seed, Registered seed, Certified seed.
5. Asexual (vegetative) propagation – advantages and disadvantages.

Unit-IV: Horticultural Practices-II

1. Natural vegetative propagation (Bulbs, Corms, Tubers, Suckers, Rhizomes, Stolons).
2. Artificial vegetative propagation – Cutting (Stem cutting – softwood cutting, semi-hardwood cutting, hardwood cutting, Herbaceous cutting; Leaf cutting, Root cutting), Factors affecting rooting in cutting.
3. Artificial vegetative propagation – Grafting (Root stock, Scion, Inter stock, Detached scion grafting & Approach grafting), Healing of graft junction, Graft incompatibility – causes and method of overcoming.
4. Artificial vegetative propagation – Budding (T budding, Patch budding, Chip budding)
5. Artificial vegetative propagation – Layering (Tip layering, Simple layering, Trench layering, Serpentine layering, Air layering, Mould layering)

Botany (Major)

SEMESTER-VI

Paper-14A (Theory)

BT-602C- Floriculture & Gardening, Pharmacognosy and Ethnobotany

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Floriculture & Gardening-I

1. Definition of Floriculture and importance & scope of Floriculture in India.
2. Ornamental plants – Flowering annuals, Herbaceous perennials, Divine vines, Shade trees, Ornamental trees, Ornamental bulbous plants, Ornamental foliage plants, Cacti & Succulents, Palms, Cycads & Ferns (Definition and three examples each from all the types).
3. Traditional flower & Cut flower (definition & example).
4. Important floricultural crops.
5. Factors affecting flower production (Quality of seed & planting material, Water, Soil, Temperature, Light, Nutrients, Diseases & pests).

Unit-II: Floriculture & Gardening-II

1. Open cultivation practice of floricultural crops.
2. Production and packaging of cut flowers.
3. Cultivation of important cut flowers - Chrysanthemum, Tuberose & Marigold.
4. Brief concept of Bio-aesthetic planning.
5. Concept of Landscape gardening and definitions of Formal garden, Informal garden, Wild garden.
6. Concept of landscaping of cities and Educational institutions.

Unit-III: Pharmacognosy

1. A brief idea on ancient Indian knowledge of Botany and medicinal plants.
2. Definition of Pharmacognosy & Pharmacology.
3. Crude drug & Commercial drug.
4. Classification of drugs – Morphological, Chemical, & Pharmacological.
5. Preparation of crude drug for commercial market.
6. Drug adulteration (types).
7. Evaluation of drugs – Physical, Chemical, Organoleptic & Microscopical.
8. Anatomical characters, active principles and pharmacological effects – Leaf of *Adhatoda*, Rhizome of *Zingiber*, Bark of *Alstonia*, Tuber of *Dioscoria sp.*
9. Source, active constituents, and pharmacological uses of some common plants - *Datura*, *Catharanthus*, *Cassia*, *Aloe*, *Asparagus*, *Centella*, *Andrographis*, *Mentha*, *Ocimum*, *Ipomoea*, *Ricinus*, *Terminalia belerica*, *Terminalia chebula*

Unit-IV: Ethnobotany

1. Definition, scope, objective and applications of Ethnobotany.
2. Methods of ethnobotanical studies – Field work, Herbarium, Ancient literature, Archaeological findings, Temples & sacred places.
3. Role of ethnic groups in the conservation of plant genetic resources.
4. Study of ethnobotanical plants of Tripura: Local name, Family, Brief description, Parts used, Ethnobotanical uses of -
 - i) **Food plants** - *Vigna unguiculata*, *Luffa cylindrical*, *Solanum violaceum*, *Solanum torvum*, *Canavalia gladiata*, *Parkia timoriana*, *Homalomena aromatic*, *Cajanas cajan*.
 - ii) **Medicinal plants** - *Hellenia speciosa*, *Andrographis paniculata*, *Oroxylum indicum*, *Holarrhena pubescens*, *Aristolochia tagala*, *Achyranthes aspera*.

Botany (Major)
SEMESTER-VI
Paper-14B (Practical)
BT-602C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No	Practicals	Marks
1.	Analysis of statistical data	06
2.	Demonstration of T-Budding / Air layering	04
3.	Study of powdered drugs OR Determination of stomatal index from leaf	06
4.	Study report on ethnobotanically important plants	04
5.	Laboratory Note book	02
5.	Viva voce	02
TOTAL		24

1. Statistical Data Analysis: Mean, Mode, Median, SD, SE, t-test.
2. Demonstration of T-Budding / Air layering.
3. Organoleptic and microscopic study of powdered drugs - Leaf of *Adhatoda*, Rhizome of *Zingiber*, Bark of *Alstonia*, Tuber of *Dioscoria sp.*
4. Determination of leaf constant stomatal index from leaf of *Adhatoda*.
5. Self study of five (05) ethnobotanically important food / medicinal plants of the locality – the study should include common name, scientific name, family, habitat, growing season, morphology (along with photograph / free hand drawing), flowering season, part used, uses etc. and the duly signed study report must be submitted during practical exam.
6. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
7. **Viva voce:** Questions based on theory (paper 13 & 14A) and practical (paper 14B) syllabus of fifth semester.

Botany (Major)
SEMESTER-VI
Paper-15 (Theory)
BT-603C- Industrial & Applied Microbiology & Algal Biotechnology

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 04)

Unit-I: Industrial & Applied Microbiology-I

1. Fermentations - Solid-state and Liquid-state (stationary and submerged) fermentations, Batch and continuous fermentations.
2. Components of a typical bioreactor, Types of bioreactors- Stirred tank fermenter, Tower fermenter, Fixed bed and Fluidized bed bioreactors, Bubble Column fermenter, and Air-lift fermenter.
3. Microbial production of industrial products - Criteria for selection of microorganisms for industrial use.
4. Microbial sources and uses of Enzyme (Amylase, Protease), Amino acid (Glutamic acid, Lysine), Polysaccharides (Dextran).
5. Microbial enzymes of industrial interest – Enzyme immobilization (concept, process and advantages).

Unit-II: Industrial & Applied Microbiology-II

1. Vaccine (definition) & its types.
2. Use of microbes as Biofertilizer – Production of Rhizobium biofertilizer.
3. Production and use of yeasts.
4. Use of microbes as Biopesticides (microbial biopesticides).
5. Use of microbes in mineral processing (microbial leaching).
6. Microbial waste water treatment and Bioremediation of contaminated soils.
7. Microbial biosensors.

Unit-III: Algal Biotechnology

1. Algae as food (foods from macro algae – Nori, Wakame, Kombu).
2. Algae as a source of SCP and cultivation of *Spirulina*.
3. Large scale production of algal biomass – Open system & Photobioreactor, Harvesting of algal biomass (dewatering) – Flocculation, Electrolysis, Gravity sedimentation, Magnetic separation, Filtration, Evaporation.
4. Algae as source of phycocolloid – source & use of Agar-agar, Algin, Carrageenan.
5. Algal Biotechnology – β -carotene, Biodiesel, Bioethanol, and Bio plastics from algae.
6. Diatomite & its use.
7. Algal toxins.

Unit-IV: Applied Mycology

1. Cheese and Ethanol- industrial production.
2. Nutritional value and cultivation of *Volvariella volvacea*, *Pleurotus sp*, and *Agaricus bisporus*.
3. Fungal sources and uses of enzyme (Cellulase), amino acid (Tryptophan), vitamin (Riboflavin) and pharmaceuticals (Cyclosporine-A).
4. Industrial production of Penicillin.
5. Industrial production of Citric acid.
6. Mycotoxins – source and effects.
7. Definition and example of Mycofungicides, Mycoherbicides, Mycoinsecticides.

Botany (Major)
SEMESTER-VI
Paper 16A (Theory)

BT-604C- Palynology & Biodiversity

Total Marks = 60 (IA = 24 + ESE = 36)

(Credits = 02)

Unit-I: Palynology

1. Pollen wall structure in Angiosperms and Difference between angiosperm & gymnosperm pollen wall.
2. Sporopollenin – Definition, chemical nature and function.
3. NPC classification (Erdtman, 1969) of pollen based on aperture – number, position and characters.
4. Types of sculpturing of pollen surface – (Psilate, Clavate, Reticulate, Scabrate, Echinate, Baculate, Verrucate, Rugulate, Foveolate, Gemmate, and Striate & Frustillate).
5. Pollen viability – Definition, Causes of loss of pollen viability, Factors affecting pollen viability.
6. Application of Palynology.
7. Paleo-palynology –Application in Stratigraphy, Paleoclimate & Hydrocarbon exploration.

Unit-II Biodiversity & its Conservation-I

1. Definition of Biodiversity, Levels of Biodiversity – Genetic diversity, species diversity, Ecosystem diversity, and Landscape diversity.
2. Species richness, Species Abundance, Species Evenness, α -diversity, β -diversity & γ -diversity (only definitions).
3. Biodiversity Hotspots & Mega diversity countries.
4. Values and uses of Biodiversity.
5. Agrobiodiversity (definition); Mono-culture (definition & effect) and Poly culture (definition & benefits).
6. Germplasm (Definition), Categories of plants under germplasm (Land races, Obsolete varieties, Cultivated varieties, Breeding lines and Wild forms & Wild relatives).
7. Gene pool (definition); Categories of Gene Pool - Primary, Secondary and Tertiary Gene Pool (only definition).

Unit-III: Biodiversity & its Conservation-II

1. **Causes of biodiversity loss –**
 - (i) **Loss of Genetic diversity** (Factors for loss of Genetic diversity – Founder effect, Demographic bottleneck, Genetic drift, Inbreeding depression).
 - (ii) **Loss of Species diversity** (processes responsible for species loss & population size and its relation to species extinction).
 - (iii) **Loss of Ecosystem diversity** (Factors responsible for loss of Ecosystem diversity).
2. **IUCN Categories** – Extinct, Endangered, Vulnerable, Rare & Indeterminate.
3. **Functions of important organizations associated with Biodiversity management** – IUCN, UNEP, WWF, FAO, and UNESCO-MAB.

Unit-IV: Biodiversity & its Conservation-III

1. Conservation strategies – Top-down and Bottom-up approaches.
2. In situ conservation – Protected area, Biosphere reserve, National Park.
3. Ex situ conservation – Botanical garden, Seed bank (Active & Base collection), Field gene bank, Pollen bank, DNA bank, Test tube gene bank.
4. Social approaches to conservation – Sacred Groves, Participatory Forest management.
5. Role of Biotechnology in conservation of Biodiversity; Cryopreservation (Principle & brief idea).

Botany (Major)
SEMESTER-VI
Paper-16B (Practical)
BT- 604C

Total Marks = 40 (IA = 16 + ESE = 24)

(Credits = 02)

Sl. No	Practicals	Marks
1.	Study of pollen sterility & fertility	07
2.	Study of Plant community parameters (Frequency, Density, Abundance & Relative abundance) from vegetation map by Quadrature method [any two]	07
3.	Submission of report on visit to local mushroom cultivation laboratory / unit	04
4.	Laboratory Note book	03
5.	<i>Viva voce</i>	03
TOTAL		24

1. Study of pollen sterility & fertility by acetocarmine staining.
2. Study of Plant community parameters (Frequency, Density, Abundance & Relative abundance) from vegetation map by Quadrature method.
3. Self visit to local mushroom cultivation laboratory / unit and duly signed report with geo-tagged photographs should be submitted during practical exam.
4. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
5. **Viva voce:** Questions based on theory (paper 15 & 16A) and practical (paper 16B) syllabus of fifth semester.

Course Structure of 4th Year Botany Major (As per NEP-2020 under Tripura University)

A. Botany Major with Honours

Year	Semester	Paper	Credits	Mark	Unit - I	Unit - II	Unit-III	Unit-IV
4 th	7 th	Paper-17 BT701C Theory	4	100 (IA=40 + ESE=60)	Plant Diversity -I	Plant Diversity -II	Advanced Plant Anatomy	Plant Taxonomy & Systematics
	7 th	Paper-18 A BT702C Theory	2	60 (IA=24 + ESE=36)	Microbiology	Medical Microbiology	Analytical Techniques - I	Analytical Techniques - II
		Pape-18B BT702C Practical	2	40 (IA=16 + ESE=24)	Based on theory papers 17 & 18A			
	7 th	Paper-19 BT703C Theory	4	100 (IA=40 + ESE=60)	Fungal Biology	Plant Cell Biology - I	Plant Cell Biology - II	Molecular Biology
	7 th	Paper-20A BT704C Theory	2	60 (IA=24 + ESE=36)	Plant Functional Biology	Plant Physiology	Biochemistry	Phytochemistry
		Paper-20B BT704C Practical	2	40 (IA=16 + ESE=24)	Based on theory papers 19 & 20A			
	8 th	Paper-21 BT801C Theory	4	100 (IA=40 + ESE=60)	Cytogenetics - I	Cytogenetics - II	Plant Biotechnology -	Plant Tissue Culture
	8 th	Paper-22A BT802C Theory	2	60 (IA=24 + ESE=36)	Ecology - I	Ecology - II	Evolution - I	Evolution - II
		Paper-22B BT802C Practical	2	40 (IA=16 + ESE=24)	Based on theory papers 21 & 22A			
	8 th	Paper-23 BT803C Theory	4	100 (IA=40 + ESE=60)	Plant Pathology	Pollination Biology	Plant Developmental Biology	Stress Physiology
	8 th	Paper-24A BT804C Theory	2	60 (IA=24 + ESE=36)	Research Methodology - I	Research Methodology - II	Fundamental Bioinformatics	Intellectual Property Rights (IPR)
		Paper-24B BT804C Practicals	2	40 (IA=16 + ESE=24)	Based on theory papers 23 & 24A			

B. Botany Major with Honours and Research

Year	Semester	Paper	Credits	Mark	Unit - I	Unit - II	Unit-III	Unit-IV
4 th	7 th	Paper-17 BT701C Theory	4	100 (IA=40 + ESE=60)	Plant Diversity -I	Plant Diversity -II	Advanced Plant Anatomy	Plant Taxonomy & Systematics
	7 th	Paper-18 A BT702C Theory	2	60 (IA=24 + ESE=36)	Microbiology	Medical Microbiology	Analytical Techniques - I	Analytical Techniques - II
		Pape-18B BT702C Practical	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 17 & 18A</i>			
	7 th	Paper-19 BT703C Theory	4	100 (IA=40 + ESE=60)	Fungal Biology	Plant Cell Biology - I	Plant Cell Biology - II	Molecular Biology
	7 th	Paper-20A BT704C Theory	2	60 (IA=24 + ESE=36)	Plant Functional Biology	Plant Physiology	Biochemistry	Phytochemistry
		Paper-20B BT704C Practical	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 19 & 20A</i>			
	8 th	Paper-21 BT801C Theory	4	100 (IA=40 + ESE=60)	Cytogenetics - I	Cytogenetics - II	Plant Biotechnology	Plant Tissue Culture
	8 th	Research Project / Dissertation	12	300	RESEARCH PROJECT			

4th Year

Botany Major with Honours / Honours & Research

Semester-VII

Paper: 17 (Theory)

BT701C - Plant Diversity, Advanced Plant Anatomy, and Plant Taxonomy & Systematics

Total Mark = 100 (IA = 40 + ESE = 60)

Credit = 04

Unit – I: Plant Diversity – I

1. Ultra structure of flagella in Algae.
2. Algal chloroplast - Origin, ultra structure and evolution.
3. Algal sexuality – (i) Origin and evolution of sex in algae, (ii) Regulation of mating types in algae (Example: *Chlamydomonas reinhardtii*)
4. Algal groups: (i) Cyanophyta - Heterocysts (structure and function) and N₂ fixation in BG algae, (ii) Rhodophyta – Cellular ultra structure, (iii) Chlorophyta – Origin of green algae - Evolutionary significance of *Prochloron*, (iv) Bacillariophyta – Frustule ultra structure and development (v) Dinophyta – General characters, Cell structure and Bioluminescence.
5. Origin of Bryophyta (Algal origin and Pteridophytic origin).
6. Alternation of generation of Bryophyta – Homologous and Antithetic theory.
7. Spore dispersal and dehiscence mechanisms in Bryophytes.
8. Ecological physiology – Mechanism of dessication tolerance in Bryophytes.
9. Evolution of gametophyte (progressive & retrogressive theories) and sporophyte (theory of progressive sterilization & theory of reduction) in Bryophyta.

Unit – II: Plant Diversity – II

1. Evolution of land plants – Changes in plant life for land adaptation, Telome Theory- Basic concept, elementary processes, and origin of sporophylls in the different groups of Pteridophytes.
2. Heterospory (definition & significance) and origin of seed habit.
3. Classification of Extant ferns (Smith et al. 2006) and their distribution.
4. Comparative study of vegetative and reproductive organs of Pteridophytes (Psilopsida, Psilotopsida, Lycopsidea, Sphenopsida, and Pteropsida).
5. Ecological diversity of ferns.
6. Progymnosperms- Origin, classification, characterization, importance in tracing evaluation of gymnosperms.
7. Gymnosperms: Recent classification as proposed by Kramer & Green (1990).
8. General account on the morphology, anatomy, and reproduction of the major groups of extant Gymnosperms – Cycadales, Ginkgoales, Coniferales, & Gnetales.

Unit – III: Advanced Plant Anatomy

1. Plant Cell Wall – Origin of cell wall during cell division, Growth and expansion of cell wall, Cell wall thickening and Pit types.
2. Epidermal tissue – Trichomes (types and functions), Epicuticular waxes – Nature and functions.
3. Ontogeny and differentiation of Xylem vessels and Sieve tubes.
4. Bark anatomy – Characters and formation of Periderm, Rhytidome, Lenticels, Polyderm, Ring bark & Scale bark.
5. Wood anatomy – Formation of wood, Soft wood & Hard wood, Sap wood & Heart wood, Characters of Gymnospermous (Coniferous) wood & Angiospermous (Dicot) wood.
6. Vascular cambium – Structure (Fusiform & Ray initials, Storied & Non-storied cambium), Factors influencing cambium activity, Cork Cambium (structure).
7. Root Stem Transitions – Types.
8. Nodal anatomy – Types.
9. Anomalous secondary growth – Stems of *Boerhaavia*, *Mirabilis*, *Bignonia*, *Nyctanthes* & *Chenopodium*

Unit – IV: Plant Taxonomy & Systematics

1. ICN - Rules of Nomenclature - Type method, Rank of taxa, Rules of Priority, Retention and rejection of names, Author Citation, Effective and valid publication.
2. APG system of classification – Principles of APG system & Brief outline of APG-III & APG-IV, Merits and Demerits of APG system.
3. Role of Embryology and Palynology in taxonomy.
4. Chemotaxonomy – (i) Definition, Important characters used in Chemotaxonomy, and Importance of Chemotaxonomy (explanation with examples), (ii) Serotaxonomy (definition).
5. Cytotaxonomy – Definition, Important characters used in Cytotaxonomy, Importance of Cytotaxonomy (explanation with examples).
6. Numerical taxonomy (Phenetics) – Definition, Principle, Steps, Advantages & Disadvantages.
7. Basics of Phylogenetic systematics (Cladistics) - Definition of following terms: (i) Cladistics & Cladogram, (ii) Plesiomorphy, Apomorphy, Synapomorphy, & Autapomorphy, (iii) Ingroup, Outgroup & OTU, (iv) Homology, Homoplasy, Convergence & Reversal, (v) Monophyletic group, Paraphyletic group & Polyphyletic group, (vi) Polytoymy & Reticulation.

Botany Major with Honours / Honours & Research

Semester-VII

Paper: 18A (Theory)

BT702C - Microbiology, Medical Microbiology and Analytical Techniques

Total Mark = 60 (IA = 24 + ESE = 36)

Credit = 02

Unit – I: Microbiology

1. Fine structure of Bacteria and Archaeal cell.
2. Bacteria growth curve and kinetics, Population death curve.
3. Bacterial Chemotaxis and its regulation.
4. Quorum sensing: Types and regulation of gene expression.
5. Cyanophages & Mycophages.
6. Lytic and Lysogenic infection – Genetic regulation.
7. Mycorrhizal and actinorhizal associations: Mechanism of infection and genetic regulation.
8. Biofilm: Formation and mechanism of antimicrobial resistance.
9. Microbial siderophores and their potential applications.
10. Antibiotics and causes of antimicrobial resistance.

Unit – II: Medical Microbiology

1. Scope and importance of medical microbiology.
2. Terms and definitions: Parasite (ecto & endo), Parasitism, Host and its types (Final, Intermediate, Transfer & Reservoir), Pathogen (Primary & Opportunistic), Pathogenic potential, Virulence, Virulence factor, Infection, Infectiveness, Infectivity, Toxin, Exo & Endo Toxin, Toxigenicity, Toxoid, LD₅₀.
3. Outline / overview of Viral and Bacterial pathogenesis.
4. Antibiotics – Broad & Narrow spectrum (with examples), Brief concept of antimicrobial resistance, Causes and its effects.
5. Viral diseases related organisms (pathogen name, symptoms, and control measures) – Pox, Influenza, Hepatitis, and HPV.
6. Bacterial diseases related organisms (disease name, symptoms, and control measures) – *Salmonella*, *Streptococcus*, and *Mycobacterium*.
7. Fungal diseases – Definition of Superficial & Cutaneous mycosis, Fungal diseases related organisms (disease name, symptoms, and control measures) – *Candida* and *Aspergillus*.
8. Uses of PCR & ELISA in medical diagnosis.

Unit – III: Analytical Techniques – I

1. **Stains and staining:** Objective, Distinction between Stain & Dye, Concept of Chromophore & Auxochrome, Mordants, Accentuators (definition), Mechanism and types of Staining, Metachromasia, Progressive staining, Regressive staining, Vital staining
2. **Microscopy:** Concept of magnification, resolution, and contrast; Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Polarized light microscopy, Fluorescent microscopy, Confocal microscopy, Electron Microscopy-TEM & SEM, Flow Cytometry (principle, sample preparation, examination).
3. **Chromatography:** Principle, types, uses - Paper chromatography, Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography, Affinity chromatography, Hydrophobic interaction chromatography, Gel Filtration chromatography.
- 4.

Unit – IV: Analytical Techniques – II

1. **Spectroscopy and Spectrophotometry:** (i) Electromagnetic radiation and interactions, Lambert-Beer law, Jablonski's diagram, (ii) Definition of: Absorbance, Emission, Transmittance, Optical density, Relative transmittance; Absorption, Scattering, Diffraction, (iii) Spectrophotometer (Single Beam & Double Beam), (iv) Resonance Spectroscopy types - Applications of UV-Vis, IR, FES, AES, XRE, XRD, DLS, NMR, ESR, FTIR, Fluorescence and Phosphorescence Spectroscopy.
2. **Centrifugation:** Principles, Concept of sedimentation coefficient, Differential and Density gradient centrifugation, Isopycnic centrifugation, Analytical centrifugation, Ultracentrifugation.
3. **Electrophoresis:** General principles, Moving Boundary electrophoresis, Zone electrophoresis, Gel electrophoresis - Horizontal & Vertical Gel electrophoresis, Agarose Gel electrophoresis, PAGE (Native PAGE, SDS PAGE), 2D protein gel electrophoresis.

Botany Major with Honours / Honours & Research

Semester-VII

Paper: 18B (Practical)

BT702C

Total Mark = 40 (IA = 16 + ESE = 24)

Credit = 02

Sl. No.	Practical	Marks
1	Workout on Algae OR Workout on Pteridophyta.	06
2	Study of Anomalous secondary growth by double staining. OR Study of Xylem vessels by maceration technique. OR Study of Nodal anatomy by serial sectioning.	06
3	Taxonomic study of angiospermic plant specimen.	08
4	Laboratory Note book	02
5	Viva Voce	02
Total		24

CONTENTS

1. Study of algal specimens along with free hand and Camera Lucida drawing of reproductive parts, determination of magnification, and identification of the genus with identifying characters – ***Oedogonium*, *Vaucheria*, *Ectocarpus*, *Polysiphonia***, and /or any other locally available freshwater algal genus (at least 04 Nos. in total).
2. Study of reproductive structure of following Pteridophytic genera – ***Marsilia*, *Dryneria*, *Adiantum*, *Lygodium*** and / or any other locally available genus (at least 04 Nos. in total).
3. Study of Anomalous secondary structures with double staining and preparation of permanent slides - Stem of: ***Boerhaavia sp.*, *Bignonia sp.*, *Chenopodium sp.*, *Nyctanthes sp.***
4. Study of Xylem vessels by maceration technique.
5. Study of Nodal anatomy by serial sectioning.
6. Workout on Angiospermic plants: Flower dissection, diagram of plant parts, description of plant, Floral formula, Floral diagram, identification up to Genus level with the help of suitable literature from the families like Solanaceae, Malvaceae, Rubiaceae, Asteraceae, Lamiaceae, and Acanthaceae and / or any locally available family.
7. Students must submit duly signed Lab Note Book.
8. Viva voce based on Paper 17 & 18.

Botany Major with Honours / Honours & Research

Semester- VII

Paper: 19 (Theory)

BT703C - Fungal Biology, Plant Cell Biology and Molecular Biology

Total Mark = 100 (IA = 40 + ESE = 60)

Credit = 04

Unit – I: Fungal Biology

1. Fungal taxonomy: Recent Classification (Kirk et. al., 2008).
2. Fungal cell wall – Composition and synthesis.
3. Mechanism of fungal growth – Budding in yeast and tip growth in filamentous fungi.
4. Fungal Sexuality: (i) Degeneration of Sex in fungi, (ii) Homothallism & Heterothallism and its genetic control, Regulation of mating system in fungi (Example – *Saccharomyces cerevisiae*).
5. Parasexuality – Stages of parasexual cycle and its significance.
6. Fungal endophytes - Definition & importance.
7. Fungi in ecosystem – Role of fungi in Biodegradation and Nutrient Cycling.

Unit-II: Plant Cell Biology - I

1. Cell-cell Interactions - Plasmodesmata, Desmosomes, Gap junctions, & Tight junctions, Hechtian Strands, Cell Wall Integrity (CWI), and Wall Associated Kinases (WAKs) in Plant Cell Wall.
2. Plasma membrane - Asymmetry, Fluidity, Adaptation to extreme temperature, FRAP, Types of transport proteins in plasma membrane.
3. Ribosome – Biogenesis, Assembly & Molecular organization.
4. Cytoskeleton – Structure and functions of Microtubules, Microfilaments, and Intermediate filaments.
5. Nuclear Ultra structure: Nuclear Lamin, Nuclear Pore Complex, Nuclear transport, Nuclear genome organization (Telomeric organization, Centromeric DNA, NOR).

Unit – III: Plant Cell Biology - II

1. Organelle Genome (mt DNA & cp DNA) – Organization and importance.
2. Cell cycle – Regulatory checkpoints and Stress response.
3. Cell signalling – (i) Types of receptors (cell surface receptor & intracellular receptor), (ii) Mechanism of GPCR. (iii) Brief idea of Ion Channel Receptors, (iv) Secondary messenger – Definition and role of cAMP, cGMP, Ca, IP3 and DAG as second messenger, (v) Brief idea on RTKs, CPTKs, JAK-STAT, MAP Kinase.
4. Programmed Cell Death and Apoptosis.

Unit – IV: Molecular Biology

1. Eukaryotic DNA replication – Mechanism and role of different protein factors.
2. Transcription in Eukaryotes - Types of RNA polymerases, Promoters, transcription factors, Initiation, Elongation and Termination.
3. Eukaryotic pre mRNA processing – Mechanism of capping on the 5' end, Polyadenylation of the 3' end, and pre-mRNA Splicing, Transport of mRNA across nuclear envelope.
4. Eukaryotic translation (Initiation, Elongation, Termination & Fidelity) and Post-transcriptional modification of proteins.

Botany Major with Honours / Honours & Research

Semester- VII

Paper: 20A (Theory)

BT704C - Plant Functional Biology, Plant Physiology, Biochemistry and Phytochemistry

Total Mark = 60 (IA = 24 + ESE = 36)

Credit = 02

Unit – I: Plant Functional Biology

1. Structure of photosynthetic complexes (PSI, PSII, and other components of photosynthetic electron transport system), Mechanism of electron transport (cyclic & non-cyclic), Q-cycle.
2. Mitochondrial electron transport complexes – Structure & mechanism of electron transport.
3. Mechanism (chemiosmotic concept) and regulation of ATP synthesis in plastid and mitochondria.
4. Reactions and Regulation of C2, C3, C4 and CAM cycles, Regulation of RUBISCO.
5. Nitrogen metabolism: Root Nodule formation, Structure of Nitrogenase complex and nitrogenase reaction, Genetic regulation of N₂ fixation, Nitrate reduction and regulation of Nitrate reductase, NH₄⁺ assimilation and formation of glutamate (GS-GOGAT pathway).
6. Glyoxylate cycle and its significance.
7. Phloem transport - Pressure flow model, Phloem loading and unloading.

Unit – II: Plant Physiology

1. Cryptochrome and Phototropin - Chemical nature and function.
2. Flower development – Flower development – Florigen concept of floral induction (CO/FT regulatory model), Specification of floral organs – ABCD+E model and role of MAD box proteins.
3. Vernalization (role of low temperature in flowering).
4. Seed dormancy –Hormonal regulation of dormancy.
5. Physiology of Senescence and Ageing – Changes during senescence, Hormonal regulation of senescence.
6. Abscission – Mechanism and hormonal regulation.
7. Micro RNA biogenesis and role in plant life.

Unit – III: Biochemistry

1. Thermodynamics- Laws and concepts, Entropy, Enthalpy, and Gibbs free energy.
2. Carbohydrates: Classification, reducing and non-reducing sugars, general properties epimers, mutarotation and anomers, Biosynthesis of Sucrose and Starch in plants.
3. Lipids: Biosynthesis of fatty acids, Fatty acid metabolism - β -oxidation and α -oxidation of fatty acid.
4. Amino acids: Classification and structure.
5. Protein structure: Primary structure (including properties of peptide bond and Ramachandran plot), Secondary structure (types and role of weak interactions), Tertiary structure (fibrous protein – example α -Keratin & Collagen and globular proteins – example Myoglobin) and Quaternary structure of proteins, Protein folding, Concept of Motif and Domain, Protein denaturation, Transamination and Oxidative deamination.
6. Nucleic acids: DNA structure, features of the double helix, various forms of DNA, denaturation and reassociation of DNA, Non Watson-Crick base pairing, Sugar puckering and base stacking, Linking Number, Writhing number and Twisting Number.

Unit – IV: Phytochemistry

1. Alkaloids – Major classes with their amino acid precursor and example.
2. Types of glycosides – O-glycoside, N-glycoside, S-glycoside & C-glycoside (with example).
3. Plant terpenoids – Major types with examples and functions.
4. Functions of Flavonoids, Anthocyanines, Tannins, Lignins, Suberins & Cyanogenic glycosides in plants.
5. Biosynthetic pathways of important secondary metabolites – (i) Acetate pathway (fatty acids and polyketides), Terpenoid biosynthesis (Mevalonate pathway & MEP pathway), Phenylpropanoid biosynthesis (Shikimic acid pathway), (ii) Formation of Lignins, Tannins and Carotenoids.
6. Biochemical tests for terpenoids, phenols, alkaloids, glycosides, saponins, flavonoids.
7. Major types of secondary metabolites with source plants and human use:
 - i. Alkaloids – Nicotine, Atropine, Reserpine, Cocaine, Colchicine.
 - ii. Glycosides – Digitoxin, Chiratin, Glycyrrhizine, Amygdalin.
 - iii. Phenolics - Caffeic acid, Coumaric acid, Gallic acid, Ferulic acid, & Rosmarinic acid.

Botany Major with Honours / Honours & Research

Semester- VII

Paper: 20B (Practical)

BT704C

Total Mark = 40 (IA = 16 + ESE = 24)

Credit = 02

Sl. No.	Practical	Marks
1	Plant Physiological Experiment.	10
2	Ash analysis for detection of mineral elements. OR Biochemical estimation.	05
3	Workout on Fungi	05
4	Laboratory Note book	02
5	Viva Voce	02
Total		24

CONTENTS

1. Plant Physiological experiments:
 - i) Determination of Osmotic Potential of *Rhoeo* leaf by plasmolytic method.
 - ii) Study of effect of temperature on absorption of water by storage tissue and determination of Q₁₀.
 - iii) Determination of loss of water per stomata per hour.
 - iv) Effect of CO₂ on the rate of Photosynthesis.
 - v) Measurement of oxygen uptake by respiring tissue (per g/hr).
 - vi) Study of catalase activity.
2. Plant Ash analysis to detect the presence of Sulphur (S), Calcium (Ca), Magnesium (Mg), Iron (Fe), and Phosphorous (P).
3. Estimation of Glucose (Titrimetric / Colorimetric), Total carbohydrate (Anthrone method), Total Protein (Lowry method), and Phenol (Folin ciocalteau method) from plant samples.
4. Workout on fungal specimens with measurement of reproductive structures, free hand drawing, and identification of genus with identifying characters – *Rhizopus* / *Mucor*, *Ascobolus*, *Puccinia*, *Agaricus*, and /or any other locally available fungal genus.
5. Students must submit duly signed Lab Note Book.
6. Viva voce based on Papers 19 & 20.

Botany Major with Honours / Honours & Research

Semester- VIII

Paper: 21 (Theory)

BT801C - Cytogenetics, Plant Biotechnology and Plant Tissue Culture

Total Mark = 100 (IA = 40 + ESE = 60)

Credit = 04

Unit – I: Cytogenetics - I

1. Karyotype concept – Definition of Karyotype, Karyogram & Idiogram; Symmetrical & Asymmetrical Karyotype, Definition of Basic number (x), Haploid number (n).
2. Chromosome banding (G-banding), Lamp brush & Polytene chromosome, B-chromosome.
3. Mechanism of X-chromosome inactivation, X-linked variegation.
4. Genetic Recombination - Mechanism for recombination between homologous DNA molecules – Holliday model.
5. Tetrad Analysis in *Neurospora sp.*
6. Chromosomal abnormalities – Down Syndrome, Patau Syndrome, Edward's Syndrome, Turner Syndrome, Klinefelter Syndrome, Cri-du-Chat Syndrome, Fragile X Syndrome.

Unit – II: Cytogenetics - II

1. Aneuploidy and Polyploidy (origin and cytological behaviour), Structural rearrangements – Insertion, Deletion, Inversion, Translocation (Structural heterozygotes and meiotic behaviour), Mosaics and Chimeras.
2. Origin of hexaploid wheat, cotton & ground nut.
3. Heritability - Narrow and Broad sense Heritability.
4. Patterns of inheritance in pedigree analysis – Autosomal dominant, Autosomal recessive, Sex linked, Sex Influenced.
5. Epigenetics - DNA methylation and its importance.
6. Maternal inheritance (Male sterility – Definition, types, and importance).

Unit – III: Plant Biotechnology

1. Molecular Cloning Vectors (Prokaryotic & Eukaryotic), Reporter Genes, Selectable Markers.
2. Protein Expression system – Expression vector (Example – pGEX), Criteria to choose a expression system, *E. coli* Protein Expression system - Components of *E. coli* expression system,
3. DNA Codominant and Dominant markers - RAPD, RFLP, SSR, AFLP, ITS
4. DNA sequencing: First generation (Maxam–Gilbert method and Sanger method) NGS and ESTs.
5. Pest resistant plant - Bt-cotton (Basic concept), Herbicide resistant plants - Round up Ready soybean, Transgenic crops with improved quality traits - Flavour Saviour tomato, Golden rice, Improved horticultural varieties - Moon dust carnations, Superbug, Edible vaccine, Humulin.

Unit – IV: Plant Tissue Culture

1. In vitro plant culture - Concept of cellular differentiation, totipotency and pluripotency.
2. Production of Virus free plant – Shoot tip / Meristem culture (Principle and protocol).
3. Definition and control of Oxidative browning of media and Vitrification.
4. Single Cell Culture – Protocol, Factors and Application of cell suspension culture.
5. Embryogenic potential, Embryoid, Somatic embryogenesis - Protocol and importance.
6. Somaclonal variation - Origin and mechanism of somaclonal variation, Significance of somaclonal variation.
7. Production of secondary metabolites through Plant Tissue Culture system (including Hairy root culture).

Botany Major with Honours

Semester- VIII

Paper: 22A (Theory)

BT802C - Ecology and Evolution

Total Mark = 60 (IA = 24 + ESE = 36)

Credit = 02

Unit – I: Ecology - I

1. Autecology, Synecology, Ecocline, Ecotype and its types.
2. Ecological Niche: Niche overlapping, Competition, Resource partitioning, and Character displacement.
3. Population ecology: Population Growth, Population Age Distribution and Age Structure, Population Dispersion pattern.
4. Community Ecology: (i) Species diversity in Community – Species Richness, Species abundance, Species Evenness, Measurement of diversity (Berger & Parker index, Simpson's Index, and Shannon Index), Keystone species, Foundation species, (ii) Community Stratification (Example – Grassland, Forest and Pond community).

Unit – II: Ecology - II

1. Ecosystem Ecology: (i) Abiotic and Biotic components, Biomass-standing crops, (ii) Productivity in Ecosystem and Ecological Efficiencies, (iii) Stability of Ecosystem – Feedback Control System (concept of Resistance & Resilience) and Redundancy.
2. Environmental Problems: (i) Basic concept of Green House Effect and Global Warming, (ii) Acid rain, (iii) Smog – Concept of classical and Photochemical smog, mechanism of formation of photochemical smog, (iv) La-Nina and El-Nino, (v) Ozone umbrella and Ozone hole, (vi) Eutrophication, (vii) Definition of Bio-entry, Bioaccumulation, Biotransformation and Biomagnification.
3. Carbon Footprint, Carbon Sequestration, Carbon Credit, Carbon Neutrality, and Carbon Offsetting (basic concept / definition).

Unit – III: Evolution - I

1. Darwinism: Concepts of variation, Adaptation, Struggle, Fitness and Natural Selection.
2. Concept of Evolutionary Synthesis.
3. Origin of genetic variation in population – factors / causes, Polymorphism – Definition, types (Balanced and Transient) and maintenance of polymorphism.
4. Selection – Effects of natural selection on population, Concept of Kin selection & Group selection.
5. Speciation - Mechanism of speciation, Hybrid speciation & Hybrid zone.
6. Adaptive radiation (including causes), Convergent evolution and Parallel evolution, Anagenesis & Cladogenesis.
7. Evolutionary Transitions - Origin of eukaryotic cells, Origin of multicellularity from unicellularity.
8. Molecular Evolution: The neutral theory of molecular evolution, Molecular clocks in evolutionary biology, Origin of new genes and proteins, Gene duplication and origin of gene families.

Unit – IV: Evolution - II

1. Concept of a primitive flower (Euanthial theory and Pseudanthial theory).
2. Origin of closed carpels – Evidences from female fructifications of Glossopteridales, Corytospermales, Caytoniales, Bennettitales, and Pentoxylales.
3. Basal living Angiosperms and concept of Paleoherbs.
4. Morphological nature and structural evolution of Stamen and Carpel.
5. Evolution of Ovule structure and Placentation types in angiosperms.

Botany Major with Honours

Semester- VIII

Paper: 22B (Practical)

BT802C

Total Mark = 40 (IA = 16 + ESE = 24)

Credit = 02

Sl. No.	Practical	Marks
1	Preparation and study of Mitotic Metaphase Plate by aceto-orcein staining method and comment on the nature of chromosomes.	07
2	Determination of Mitotic index in <i>Allium cepa</i> / <i>Allium sativum</i> . OR Temporary preparation and study of different stages of meiosis from the flower buds of <i>Allium cepa</i> .	06
3	Determination of minimum Quadrate size. OR Calculation of Diversify indices (as prescribed in theory syllabus) OR Estimation of dissolved O ₂ content.	05
4	Laboratory Note book	03
5	Viva Voce	03
Total		24

CONTENTS

1. Preparation and study of Mitotic Metaphase Plate by aceto-orcein staining method and preparation of permanent slides from the following materials: *Allium cepa*, *Allium sativum*, *Lens esculentus*, *Aloe vera*, *Pisum sativum*, *Nigella sp.* (any three).
2. Determination of Mitotic index in *Allium cepa* / *Allium sativum*.
3. Temporary preparation and study of different stages of meiosis from the flower buds of *Allium cepa*.
4. Determination of minimum Quadrate size.
5. Calculation of Diversify indices (as prescribed in theory syllabus).
6. Estimation of dissolved O₂ content.
7. Students must submit duly signed Lab Note Book.
8. Viva voce based on Papers 21 & 22.

Botany Major with Honours

Semester- VIII

Paper: 23 (Theory)

BT803C - Plant Pathology, Pollination Biology, Plant Developmental Biology and Stress Physiology

Total Mark = 100 (IA = 40 + ESE = 60)

Credit = 04

Unit – I: Plant Pathology

1. Stages of disease development in plants – Inoculation (types, sources & arrival of inoculum), Pre-penetration, Penetration (direct penetration & penetration through wounds and opening), Post-penetration (infection process), Dissemination of pathogen & Overwintering / oversummering.
2. Role of pathogenicity genes in plant disease development.
3. Physiology of diseased plants - Effects of diseases on physiological parameters (Photosynthesis, Respiration, Protein synthesis, Nucleic acid metabolism & Phenol metabolism)..
4. Plant Defence system – Non Host resistance, Horizontal resistance & Vertical resistance, Role of R-gene in resistance.
5. Pre-existing structural and chemical defence in plants.
6. Induced structural defence in plants – Cell wall defence structure, Formation of cork layer, Formation of abscission layer, Formation of tyloses, Deposition of gums.
7. Induced biochemical defence in plants – Role of pathogenesis related proteins, Phenolics & Phytoalexins.

Unit – II: Pollination Biology

1. Pollination types and their Contrivances.
2. Self Incompatibility – Heteromorphic system & Homomorphic system (Gametophytic & Sporophytic systems), Methods of overcoming self incompatibility.
3. Mechanism for pollen reception, pollen tube growth and fertilization.
4. Major types of pollinating agents: Pollination syndrome (definition), Traits of flowers pollinated by Water, Air, Bee, Butterfly, Fly, Bird and Bat.
5. Pollination Guild: Definition and characteristics.
6. Mechanism for pollen reception and pollen tube growth.
7. Pollinator crisis – Definition, Factors responsible for Pollinator crisis.

Unit – III: Plant Development Biology

1. Seed germination– Mobilization of food reserves and role of growth regulators in seed germination.
2. Organization of shoot apex -Apical cell theory, Histogen theory, Tunica Corpus theory, Neuman's Theory of Continuing Meristematic Residue, Cyto-Histological Zonation Theory.
3. Initiation of leaf primordia and development of leaves.
4. Organisation of root apex -Apical cell theory, Histogen theory, Korper - Kappe theory; structure and function of root apex- quiescent centre; Root cap.
5. Root development – Establishment of primary root meristem, Lateral root development.
6. Embryo maturation and seed development – Changes during embryo maturation and seed development and their hormonal regulation.
7. Fruit ripening – climacteric and non-climacteric ripening, changes during ripening (including role of ethylene in ripening).

Unit – IV: Stress Physiology

1. Definition of stress in respect to plants; Concept of Stress avoidance, Stress tolerance, Acclimation & Adaptation.
2. High Light Stress – Concept of photoinhibition and photoprotection (mechanical and biochemical protection).
3. Water stress (water deficit and drought resistance) – Effects of water stress on plants and response to water stress (physiological, biochemical & molecular responses).
4. Temperature stress (Heat stress & Heat shock) – Effects of heat stress on plants and Plant adaptation to heat stress - mechanism of avoidance & mechanism of tolerance, Role of heat shock proteins (HSPs).
5. Salinity stress – effects of salinity on plants, salt tolerance and its mechanism.

Botany Major with Honours

Semester- VIII

Paper: 24A (Theory)

BT804C - Research Methodology, Fundamental Bioinformatics and Intellectual Property Rights

Total Mark = 60 (IA = 24 + ESE = 36)

Credit = 02

Unit-I (Research Methodology-1)

1. Definition and meaning of research.
2. Characteristics of research / Criteria for good research – Objectivity, Reliability, Validity, Credibility, Generalizability, Replicable.
3. Objective / Purpose of research, Research Ethics (important ethical considerations).
4. Some important categories of research – (i) Descriptive & Analytical, (ii) Fundamental & Applied, (iii) Quantitative & Qualitative, (iv) Conceptual & Empirical, (v) Inductive & Deductive, (vi) Action research.
5. Process of Research – (i) Formulating the research problem, (ii) Extensive literature survey (iii) Developing the hypothesis, (iv) Preparing the research design, (v) Determining sample design, (vi) Collecting the data, (vii) Execution of the project, (viii) Analysis of data, (ix) Hypothesis testing, (x) Generalisations and interpretation, (xi) Preparation of the report or presentation of the results.
6. Formulation of research problem: Factors affecting the selection of research problem – (Types of Internal & External factors).
7. Research design – Features of good research design; Three principles of experimental designs: (i) the Principle of Replication; (ii) the Principle of Randomization (iii) Principle of Local Control.

Unit-II (Research Methodology-2)

1. Types of sampling – Probability sampling (Simple random sample, Stratified random sample, Cluster sample), Non-probability sampling (Quota sampling, Purposive sampling, Convenience sampling, Snowball sampling).
2. Hypothesis – Features of good hypothesis, Types of hypothesis – Descriptive, Relational, Explanatory, Null hypothesis, Alternative.
3. Variables – Types of variables (Continuous & Discrete, Dependable & Independent, Extraneous, Confounding, Categorical, Demographic), Univariate & Bivariate Data, Ways of measuring variables – Nominal scale, Ordinal scale, Interval scale, Ratio scale.
4. Methods of data collection – (i) Observation, (ii) Questionnaires, Types of questions - Open-ended, Closed-ended (Simple dichotomy and Multiple choice – Determinant choice & Checklist question), (iii) Interviews (Structured, Semi-structured, Unstructured), (iv) Focus Group Discussion
5. Report writing – General layout of report.
6. Bibliography & Reference (definition & difference).

Unit – III: Fundamental Bioinformatics

1. Definition, Aims and Scope of Bioinformatics, Bioinformatics as interdisciplinary subject.
2. Concept of branches of Bioinformatics – Genomics, Proteomics, Transcriptomics, Systems Biology, Functional Genomics, Metabonomics, Structural genomics, Cheminformatics, Molecular Phylogeny.
3. Definition of Database and Biological Database, Features of Biological database, Definition of Primary database and Secondary database, Classification of biological database based on data types (brief idea with examples) – Sequence databases, Genome databases, Bibliographic databases, Microarray databases, Metabolic databases, Chemical databases, Structural databases, Disease databases and Enzyme databases.
4. Concept of File format of biological database, File format types (definition and examples) - Sequence file formats and Molecular file formats.
5. Brief idea of BLAST – Standard BLAST and Mega BLAST, Application of BLAST tool in Biological Science.
6. NCBI and its role.
7. Basic concept of Protein Data Bank (PDB).

Unit – IV: Intellectual Property Rights (IPR)

1. Definition of Intellectual Property (IP) & Intellectual Property Right (IPR).
2. Importance of IP in the economic and cultural development of the society.
3. Important categories of IPR:
 - i) Patents – Definition of Patent, Conditions for Obtaining a Patent Protection, Rights Associated with Patents, Inventions Eligible for Patenting, Non-Patentable Matters.
 - ii) Copyright – Definition of Copyrights, Criteria for Copyright, Ownership of Copyright, Copyright Infringement, Non-Copyright works.
 - iii) Trade Marks – Definition of Trade Marks, Eligibility criteria for Trade Marks, Designation of Trade Mark symbol.
 - iv) Geographical Indications (GI) – Definition of GI, Rights granted to the holders of GI.
 - v) Trade Secrets – Definition of Trade Secrets, Criteria for Trade Secrets, Rights associated with Trade Secrets.
 - vi) Traditional Knowledge (TK) – Definition and importance of TK.
 - vii) Plant variety – Definition of Plant Variety, Need for plant protection as IP, Conditions for registration of new plant variety, Types of plant varieties registered under PVP & FR act.

Botany Major with Honours

Semester- VIII

Paper: 24B (Practical)

BT804C

Total Mark = 40 (IA = 16 + ESE = 24)

Credit = 02

Sl. No.	Practical	Marks
1	Study of in vitro pollen germination.	05
2	Study of effect of salinity stress / heat stress on physiological process of plants (rate of Photosynthesis). OR Study / estimation of amylase activity in germinated seeds.	09
3	Retrieval of Nucleotide sequence or Protein sequence from GenBank (NCBI)	04
4	Laboratory Note book	03
5	<i>Viva Voce</i>	03
Total		24

CONTENTS

1. Study of in vitro pollen germination and determination of germination percentage.
2. Study of effect of salinity stress (different NaCl concentration) / heat stress (different temperature) on physiological process of plants (rate of Photosynthesis).
3. Study / estimation of amylase activity in germinated seeds.
4. Retrieval of Nucleotide sequence and Protein sequence from GenBank (NCBI): Online demonstration and schematic representation of the retrieval procedure.
5. Students must submit duly signed Lab Note Book.
6. Viva voce based on Papers 23 & 24.



Tripura University
(A Central University)
Suryamaninagar
West Tripura

Syllabus for
Four Years Undergraduate Programme
Subject: Botany (Minor)
(As per NEP-2020)

Year - 2023



Tripura University
(A Central University)

Course Structure of Botany (UG Programme)

As per NEP-2020 under Tripura University

BOTANY (MINOR)

Year	Semester	Paper	Credits	Total marks	Unit-I	Unit-II	Unit-III	Unit-IV
1st	1st	Paper-1A Theory	3	60 (IA=24+ ESE=36)	Microbiology	Phycology-I	Phycology-II	Mycology
		BT101M Paper-1B Practical	1	40 (IA=16+ ESE=24)	Based on theory paper 1A			
	2nd	Paper-2A Theory	3	60 (IA=24+ ESE=36)	Bryophyta	Pteridophyta	Gymnosperm	Paleobotany
		BT201M Paper-2B Practical	1	40 (IA=16+ ESE=36)	Based on theory paper 2A			
2nd	3rd	Paper-3A Theory	3	60 (IA=24+ ESE=36)	Phytopathology	Morphology	Embryology	Plant Anatomy
		BT301M Paper-3B Practical	1	40 (IA=16+ ESE=24)	Based on theory paper 3A			
	4th	Paper-4A Theory	3	60 (IA=24+ ESE=36)	Taxonomy-I	Taxonomy-II	Plant Ecology	Phytogeography
		BT401M Paper-4B Practical	1	40 (IA=16+ ESE=24)	Based on theory paper 4A			
3rd	5th	Paper-5A Theory	3	60 (IA=24+ ESE=36)	Biochemistry	Plant Physiology-I	Plant Physiology-II	Evolution
		BT501M Paper-5B Practicals	1	40 (IA=16+ ESE=24)	Based on theory paper 5A			
	6th	Paper-6A Theory	3	60 (IA=24+ ESE=36)	Cell Biology	Molecular Biology-I	Molecular Biology-II	Genetics
		BT601M Paper-6B Practical	1	40 (IA=16+ ESE=24)	Based on theory paper 6A			
4th	7th	Paper-7A Theory	3	60 (IA=24+ ESE=36)	Biometry	Plant Breeding	Economic Botany-I	Economic Botany-II
		BT701M Paper-7B Practicals	1	40 (IA=16+ ESE=24)	Based on theory paper 7A			
	8th	Paper-8A Theory	3	60 (IA=24 + ESE=36)	Plant Biotechnology-I	Plant Biotechnology-II	Pharmacognosy	Biodiversity & Sustainable development
		Paper-8B Practicals	1	40 (IA=16+ ESE=24)	Based on theory paper 8A			

**DETAILED COURSE CONTENT OF
BOTANY (MINOR)**

Botany (Minor)

SEMESTER-I

Paper-1A- (Theory)

BT-101M – Microbiology, Phycology & Fungi

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-1: Microbiology

1. **Virus:** General properties of plant virus and Bacteriophage, Structure of DNA virus (T4 phage); Lytic and lysogenic cycle; Structure of RNA virus (TMV).
2. **Bacteria:** General characters of bacteria; Morphological forms, Cell structure (in detail), Bacterial reproduction- binary fission and endospore formation, Genetic recombination in bacteria -(transformation, transduction and conjugation).

Unit-II: Phycology-I

1. General characters of Algae - Thallus organization, Pigments, Outline classification of Lee (1999) up to phylum, Economic importance of algae, *Spirulina* cultivation.
2. Salient features of Cyanophyceae, Chlorophyceae, Phaeophyceae and Rhodophyceae.
3. Bacillariophyceae (Diatom) - Cell structure, reproduction and economic importance.

Unit-III: Phycology-II

Life history of the following: *Nostoc*, *Oedogonium*, *Chara*, *Ectocarpus* and *Polysiphonia*.

Unit-IV: Mycology

1. General characters of Fungi including fungal mode of nutrition, Classification of Fungi (Ainsworth, 1973) up to sub-division; Economic importance of fungi.
2. Important characteristics of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, & Deuteromycotina.
3. General characters of Myxomycetes.
4. Life history of *Rhizopus*, *Penicillium* & *Agaricus*.
5. Mushroom production and harvesting (*Volvariella* sp. and *Pleurotus* sp.).

Botany (Minor)
SEMESTER-I
Paper-1B-(Practical)
BT-101M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No.	Practical	Marks
1.	Workout on Microbiology	07
2.	Workout on Algae or Workout on Fungi*	07
3	Identification with reasons (2 x 2 marks)	04
4.	Laboratory Note book	03
5.	Viva voce	03
TOTAL		24

CONTENTS

1. Use of Simple and Compound microscope.
2. **Work out on Microbiology:**
 - (a) Gram staining of bacterial population from curd.
 - (b) Demonstration of Sterilization process.
3. **Work out of the following algal genera** with reproductive structures (Free hand drawing only): *Nostoc* sp., *Oedogonium* sp., *Chara* sp., *Ectocarpus* sp., *Polysiphonia* sp.
And
Work out of the following Fungi with reproductive structures (Free hand drawing): *Rhizopus* sp., *Penicillium* sp., *Agaricus* sp., *Polyporus* sp.

**Algal and fungal specimen should be given alternatively to the students during exam.*
4. **Identifications:**
 - a) **Permanent slides of Algae:** *Nostoc*, *Volvox* colony, *Oedogonium* dwarf male, *Polysiphonia* – cystocarp & tetrasporophyte.
 - b) **Permanent slides of Fungi:** Zygosporangium of *Rhizopus*, Conidiophore of *Penicillium*, T.S. of gills of *Agaricus*, T.S. of basidiocarp of *Polyporus*.
 - c) **Macro specimen** - Fruitbody of *Agaricus*, *Polyporus*.
5. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
6. **Viva voce:** Questions based on theory and practical syllabus of 1st semester.

Botany (Minor)

Semester-II

Paper-2A (Theory)

BT- 201M – Bryophyta, Pteridophyta & Gymnosperms and Paleobotany

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Bryophyta

1. General characters including Amphibian nature; Origin of Bryophyta.
2. Distinctive features of three major groups – Hepaticopsida, Anthocerotopsida, & Bryopsida.
3. Life history: Gametophyte structure & reproduction, development and structure of sporophyte in of *Riccia*, *Marchantia*, *Anthoceros*, and *Funaria*.

Unit-II: Pteridophyta

1. General characters, Lifecycle pattern (Homosporous & Heterosporous type).
2. Outline classification (Sporne, 1975) up to order with examples.
3. Important characters of the classes – Psilophytopsida, Psilotopsida, Lycopsida, Sphenopsida, Pteropsida.
4. Life history: Sporophyte structure, reproduction and structure of gametophyte of *Lycopodium*, *Selaginella*, *Equisetum*, and *Pteris*.

Unit-III: Gymnosperms

1. General characters of Progymnosperms.
2. Gymnosperms - General characters.
3. Outline classification (Sporne, 1965) up to Order with examples.
4. Important characters of three classes – Cycadopsida, Coniferopsida, & Gnetopsida.
5. Economic importance of Gymnosperms with reference to Wood, Resins, Essential oils, and Drugs.
6. Life cycle (Morphology, anatomy and reproduction) of *Cycas*, *Pinus* and *Gnetum*.

Unit-IV: Paleobotany:

1. Definition of fossil, Conditions required for fossilization, Fossilization process.
2. Types of fossil (Microfossil, Mega fossil and its types on the basis of nature of fossilization); Modes of preservation (after Schopf, 1975).
3. Importance of fossil study.
4. Geological Time scale with dominant plant groups through ages.
5. Study of fossil plants:- *Rhynia*, *Williamsonia*

Botany (Minor)
Semester-II
Paper-2B (Practical)
BT- 201M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No.	Practical	Marks
1.	Workout on Pteridophyta	07
2.	Workout on Gymnosperm	07
3	Identification with reasons (2 x 2 marks)	04
4.	Laboratory Note book	03
5.	Viva voce	03
TOTAL		24

CONTENTS

1. Work out on:

- (a) **Pteridophytes:** Workout on reproductive structures of the following Pteridophytes: *Lycopodium* sp., *Selaginella* sp., *Equisetum* sp., *Pteris* sp.
- (b) **Gymnosperms:** Leaflet of *Cycas* sp, Needle leaf of *Pinus* sp., Microsporophyll of *Cycas* sp.

2. Identification:

- (a) **Study of Bryophytes from permanent slides** – *Riccia* (V.S. of thallus), *Marchantia* (L.S. of: Gemma cup, antheridiophore, archegoniophore, sporophyte), *Anthoceros* (L.S. of sporophyte), *Funaria* (L.S. capsule).
- (b) **Study of macroscopic structures of Gymnosperm:** *Cycas* microsporophylls, *Cycas* megasporophyll, *Pinus* male cone, *Pinus* female cone, *Gnetum* male cone, *Gnetum* female cone.
- (c) **Study of Gymnosperms from permanent slides** – L.S. of *Cycas* ovule, L.S. of *Pinus* male cone, L.S. of *Pinus* female cone, Pollen grains of *Pinus*, L.S. of *Gnetum* male cone, L.S. of *Gnetum* female cone/ovule.
- (d) Study from permanent slides/macroscopic fossil specimen.

3. Laboratory Records: Student must get the laboratory note books duly signed by the respective teacher during practical classes.

4. Viva voce: Questions based on theory and practical syllabus of 2nd semester.

Botany (Minor)

Semester-III

Paper- 3A (Theory)

BT- 301M- Phytopathology, Morphology & Plant Anatomy

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Phytopathology

1. Terms and concepts (Infection ,disease, Pathogen, Pathogenecity, Pathogenesis, Incubation period, Symptom, Necrotroph, , Inoculum, Inoculum potential, Causal complex, Disease cycle, Endemic disease, Epidemic disease, Sporadic disease);Koch's postulates, Types of symptoms (Necrotic, Atrophic, Hypertrophic); Plant quarantine.
2. Symptoms, Casual organisms, Disease cycle and Control measures of the following diseases: Late blight of Potato, Brown sport of Rice, Black stem rust of Wheat.

Unit-II: Morphology

1. Root- Types and modification.
2. Leaf – Types, Shape of lamina, Apex, Margin, Phyllotaxy, Venation, Stipule types.
3. Inflorescence - types with examples.
4. Flower - Flower types, Floral parts- Calyx (types & modifications), Corolla (types & forms), Aestivation; Stamens (types, cohesion andadhesion); Carpel (Apocarpous and Syncarpous), Ovary (types), Style (types), Placentation types.
5. Fruits- types.
6. Seed types and their dispersal.

Unit-III: Embryology

1. Microsporogenesis.
2. Megasporogenesis (types – monosporic, bisporic & tetrasporic).
3. Structure of ovule and its type.
4. Process of double fertilization.
5. Embryo development (dicot & monocot type),
6. Endosperm development – Nuclear, Cellular & Hellobial types.

Unit-IV: Plant Anatomy

1. Cell wall (Chemical composition & Gross structure).
2. Meristematic tissue: General characters & Classification.
3. Permanent tissue (structure, distribution and function).
4. Cell types of Xylem and Phloem, Vascular bundles – Types; Stele – Types.
5. General anatomical characters of monocot stem and root, Dicot stem and root, Dorsiventral and isobilateral leaf.
6. Normal secondary growth in dicot stem and root.

Botany (Minor)
Semester-III
Paper-3B (Practical)
BT-301M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No.	Practical	Marks
1.	Workout on Anatomy	08
2.	Identification with reasons (4 x 2 marks)	08
3.	Laboratory Note book	04
4.	Viva voce	04
TOTAL		24

CONTENTS

- 1. Work out on Plant Anatomy:** Study of Primary structures by preparing temporary slides of the following: **Monocot stem:** T. S. of *Canna* scape / T. S. of Maize stem, **Dicot stem:** T. S. of *Cucurbita* stem / T. S. of Sunflower stem, **Monocot root:** T. S. of Arum root / T. S. of Orchid root, **Dicot root:** T. S. of *Pisum* root, **Dorsiventral leaf:** T. S. of Mango leaf, Isobilateral leaf: T. S. of Bamboo leaf / T. S. of *Phoenix* leaf.
- 2. Identification:**
Types of placentation: Study of different types of placentation.
Types of fruits: Study from fresh or preserved specimens.
Minor anatomy: Types of Stomata, Cystolith, Raphides, Starch grains.
Pathological specimens (fresh or preserved): Name of the disease, Name of Pathogen, symptoms, Identifying characters of – Late blight of Potato, Brown sport of Rice, Black stem rust of Wheat.
- 3. Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
- 4. Viva voce:** Questions based on theory and practical syllabus of 3rd semester.

Botany (Minor)
Semester-IV
Paper- 4A (Theory)

BT- 401M - Plant Taxonomy, Plant Ecology & Phytogeography

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit I: Plant Taxonomy-I

1. Components of Plant taxonomy (identification, nomenclature, classification).
2. Aims and phases of taxonomy.
3. Elementary knowledge of ICN- Principles.
4. Herbaria and Botanical Gardens – Functions of Herbaria and Botanical Gardens , Important Herbaria and Botanical Gardens of India and world (3 each).
5. History of Plant classification: Artificial (Linnaeus), Natural (Bentham & Hooker) and Phylogenetic (Hutchinson).

Unit II: Plant Taxonomy-II

Study of the following families (Diagnostic characters, General characters & Economic importance):

Poaceae, Orchidaceae, Magnoliaceae, Leguminosae (with sub- families Caesalpiniaceae, Mimosaceae, Papilionaceae), Malvaceae, Cucurbitaceae, Brassicaceae, Solanaceae, Apocynaceae, Lamiaceae, Rubiaceae and Asteraceae.

Unit-III: Plant Ecology

1. Soil- Origin, Formation, Composition, Physical and Chemical properties, Soil types; Water – Types of soil water.
2. Basic ecological concepts (Trophic levels, Food chain, Food web, Ecological pyramids, Energy flow, Production and Productivity).
3. Habitat and Ecological niche (definition).
4. Succession - Hydrosere and Xerosere.
5. Adaptations of Hydrophytes, Xerophytes and Halophytes.
6. Biogeochemical cycles - Cycling of Carbon and Nitrogen.
7. Red Data book.

Unit-IV: Phytogeography

1. Phytogeographical regions of India (D. Chatterjee, 1960),
2. Vegetations of Eastern Himalaya, Western Himalaya, Sunderban, and Tripura.
3. Endemism - Definition, types, theories of endemism & factors responsible for endemism.

Botany (Minor)
Semester-IV
Paper-4B (Practical)
BT-401M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No.	Practical	Marks
1.	Workout on Angiospermic plant	08
2.	Workout on Ecological anatomy	05
3	Spot identification of plants (2 x 1 mark)	02
4.	Submission of Herbarium sheets	03
5.	Laboratory Note book	03
6.	<i>Viva voce</i>	03
TOTAL		24

CONTENTS

1. **Workout on Angiospermic plants:** Flower dissection, diagram of plant parts, floral diagram, description of plant, floral formula, identification of the family from the families included in the theory syllabus.
2. **Study of Ecological anatomy:** Hydrophytes (*Hydrilla* stem / *Nymphaea* petiole), Xerophytes (*Nerium* leaf).
3. **Spot identification:** Scientific names of common wild plants from the families included in theory syllabus.
4. **Submission of Herbarium sheets:** At least **15 herbarium sheets** must be submitted.
5. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
6. **Viva voce:** Questions based on theory and practical syllabus of 4th semester.

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Biochemistry

1. Water molecule – general properties.
2. Carbohydrates – Classification with example.
3. Lipids – Classification with example & function.
4. Proteins - Levels of protein structure, Classification of proteins with example and biological roles.
5. Nucleic acids - Types of DNA and RNA; Enzymes: General properties and classification with examples.

Unit-II: Plant Physiology-I

1. Water potential and its components and their relation, Osmosis, Plasmolysis.
2. Water absorption by roots (Apoplastic and Symplastic pathways), Ascent of sap - Cohesion-tension theory.
3. Transpiration and antitranspirant.
4. Photosynthesis: Structure of PSI and PSII, Photosynthetic electron transport (Cyclic & non-cyclic), C3 cycle, C4 cycle, CAM cycle.

Unit-III: Plant Physiology-II

1. Glycolysis, Oxidative decarboxylation, TCA cycle, Mitochondrial electron transport, Oxidative Phosphorylation and ATPsynthesis.
2. Photorespiration; Photoperiodism: Photoperiodic responses and classification of plants.
3. Source, physiological role and mode of action of IAA, Gibberellins and Cytokinins.
4. Nitrogen metabolism: Biological N₂ fixation (nodule formation, role of Nitrogenase and leg hemoglobin), function of *nif* and *nod* genes.

Unit-IV: Evolution

1. Origin of life (Oparin-Haldane concept, Urey-Miller experiment, RNA world hypothesis, Protein first model).
2. Biological species concept, Modes of speciation (Allopatric, Peripatric, Parapatric, & Sympatric); Natural selection - Definition and types (Directional, Stabilizing, Disruptive).
3. Macro and Micro evolution (definition).
4. Darwinism and its limitations, Neo Darwinism (only brief idea).

Botany (Minor)
Semester-V
Paper-5B (Practical)
BT-501M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No	Practical	Mark
1.	Detection of Biochemical compound from unknown sample.	06
2.	Plant Physiology experiment	12
3.	Laboratory Note book	03
4.	<i>Viva voce</i>	03
TOTAL		24

CONTENTS

1. Biochemical compound detection:

(a) **Detection of the nature of carbohydrate:** Glucose, Fructose, Sucrose & Starch.

(b) **Detection of organic acids:** Oxalic acid, Tartaric acid, Citric acid.

2. Plant Physiological experiments:

- i. Comparison of imbibitions of water by Starchy, Proteinaceous and Fatty seeds.
- ii. Comparison of water loss in dorsiventral leaf by Cobalt Chloride method.
- iii. Relationship between transpiration and evaporation.
- iv. Separation of Chlorophyll pigments by paper chromatography.
- v. Determination of released oxygen during photosynthesis (ml/gm/hr).
- vi. Measurement of oxygen uptake by respiring tissue (per gram/hour).

3. Laboratory Records: Student must get the laboratory note books duly signed by the respective teacher during practical classes.

4. Viva voce: Questions based on theory and practical syllabus of 5th semester.

Botany (Minor)

Semester-VI

Paper- 6A (Theory)

BT-601M- Cell biology, Molecular Biology & Genetics

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Cell biology

1. Composition and structure of Plasma membrane.
2. Structural organization and functions of Mitochondria, Chloroplast, Endoplasmic reticulum, Ribosome, Semiautonomous nature of Mitochondria and Chloroplast.
3. Structure of Nucleus; Chromosome morphology and organization of eukaryotic chromosome (Nucleosome concept), Euchromatin and Heterochromatin, Telomere & Centromere (properties).
4. Cell cycle – Various phases & events (G1, S, G2, M), Cell division- Stages of Mitosis & Meiosis.

Unit-II: Molecular Biology-I

1. Nucleoside and Nucleotide, DNA structure (Watson & Crick model).
2. Central Dogma of molecular biology.
3. DNA replication - General properties & DNA replication mechanism in prokaryotes.
4. Transcription- Initiation, Elongation and Termination in prokaryotes.

Unit-III: Molecular Biology-II

1. Genetic code- Properties.
2. Translation in prokaryotes.
3. Regulation of Gene expression in Prokaryotes - Operon model (general concept), mechanism of lac-operon.
4. Gene mutation- Base substitution (Transition & Transversion) and Frame shift mutation.

Unit-IV: Genetics

1. Mendelian genetics-Principles of segregation and independent assortment; Concept of Dominance, Incomplete dominance, Codominance.
2. Gene interactions with modified dihybrid ratios (12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1).
3. Definition of Penetrance, Expressivity, Pleiotropism, Phenocopy effect.
4. Linkage (definition of complete, incomplete, coupling phase and repulsion phase linkage, linkage group) and Crossing over & its cytological basis (McClintock experiment).
5. Chromosomal aberration- Numerical changes (aneuploidy and euploidy), Polyploidy types, Structural changes (definition and types of deletion, duplication, inversion and translocation).

Botany (Minor)
Semester-VI
Paper-6B (Practical)
BT-601M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No	Practical	Mark
1.	Work out on Mitotic stages	10
2.	Identification with reasons (3 x 2 marks)	06
3.	Laboratory Note book	04
4.	<i>Viva voce</i>	04
TOTAL		24

CONTENTS

- 1. Work out on Mitotic study:** Temporary preparation of mitotic stages from directly fixed root tips of *Allium cepa*.
- 2. Identification:** Study of different stages of Mitosis and Meiosis (Normal and /or Abnormal) from permanent slides.
- 3. Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
- 4. Viva voce:** Questions based on theory and practical syllabus of 6th semester.

Botany (Minor)

Semester-VII

Paper- 7A (Theory)

BT- 701M - Biometry, Plant Breeding & Economic Botany

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Biometry

1. Presentation of statistical data – Concept of variable and attribute, Primary and Secondary data, Population and Sample, Frequency and frequency distribution, Graphical presentation of data – Bardigram & Histogram, Pie chart.
2. Measures of central tendency (Mean, Mode, Median).
3. Measures of dispersion (Mean deviation, SD, SE).
4. Test of significance – Null hypothesis and Alternate hypothesis, Degree of Freedom, Level of Significance, Student t-test, chi square test for Goodness of fit.

Unit-II: Plant Breeding

1. Aims of plant breeding.
2. Methods of plant breeding: Plant introduction, Acclimatization, Plant domestication.
3. Selection-Mass selection, Pureline selection, Clonal selection.
4. Hybridization (different steps) & Production of synthetic variety.
5. Heterosis (definition, genetic and biochemical basis, importance in plant breeding) & Inbreeding depression.
6. Male sterility (definition, types, importance in plant breeding).

Unit-III: Economic Botany-I

Scientific name, family, part used, and uses of following plants:

Cereal – Rice, Wheat; **Pulses** – Gram, Moong and Lens; **Beverages** – Tea and Coffee; **Fruits** – Mango, Citrus and Papaya; **Drug yielding** – Cinchona, Rauwolfia, Digitalis, Papaver, Andrographis; **Spices** – Ginger, Cumin and Clove; **Oil yielding** – Mustard, Groundnut, Coconut and Linseed; **Vegetables** – Potato, Radish and Cabbage; **Fibre yielding** – Cotton and Jute; **Timber yielding** – Teak and Sal; **Sugar yielding** – Sugarcane.

Unit-IV: Economic Botany-II

1. Rice cultivation- Conventional method & SRI system.
2. Jute Cultivation and processing.
3. Tea cultivation and processing (orthodox & CTC methods).
4. Rubber cultivation and processing.

Botany (Minor)
Semester-VII
Paper-7B (Practical)
BT- 701M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No	Practical	Mark
1.	Testing goodness of fit of modified di-hybrid ratios (12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1)	08
2.	Study of economically important plants (Scientific name, Family, Economically important part, and Uses) as per theory syllabus (2 x 4 marks)	08
3.	Laboratory Note book	04
4.	<i>Viva voce</i>	04
TOTAL		24

CONTENTS

- 1. Biometry:** Determination of goodness of fit (chi square test) of modified di-hybrid ratios(12:3:1, 9:7, 9:3:4, 9:6:1, 13:3, 15:1).
- 2. Study of economically important plants** (Scientific name, Family, Economically important part, and Uses of the prescribed syllabus).
- 3. Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
- 4. Viva voce:** Questions based on theory and practical syllabus of 7th semester.

Botany (Minor)
Semester-VIII
Paper-8A (Theory)
BT- 801M - Plant Biotechnology, Pharmacognosy & Biodiversity

Total Marks-60 (IA = 24 + ESE = 36)

(Credits-3)

Unit-I: Plant Biotechnology-I

1. Totipotency and concept of plant tissue culture.
2. Function and organization of a typical plant tissue culture laboratory.
3. Composition of plant tissue culture medium.
4. Techniques of plant tissue culture: Callus culture, Cell suspension culture technique, Haploid culture and Embryo culture.
5. Definition of micropropagation and importance.

Unit-II: Plant Biotechnology-II

1. Definition of Recombinant DNA technology.
2. Enzymes in DNA cloning – Restriction endonuclease (Type I, II & III).
3. Definition of cDNA library and Genomic library.
4. Criteria for good Vector, Brief concept of cloning Vectors (plasmid, lambda phage, YAC).
5. Production of transgenic plant: *Agrobacterium* mediated gene transfer.

Unit-III: Pharmacognosy

1. Definition of Pharmacognosy & Pharmacology, Crude drug & Commercial drug.
2. Classification of drugs – Morphological, Chemical, & Pharmacological.
3. Preparation of crude drug for commercial market.
4. Drug adulteration (types).
5. Evaluation of drugs – Physical, Chemical, Organoleptic & Microscopical.
6. Anatomical characters, active principles and pharmacological effects – Leaf of *Adhatoda*, Rhizome of *Zingiber*, Bark of *Alstonia*, and Tuber of *Dioscoria* sp.

Unit-IV: Biodiversity & Sustainable development

1. Definition, Levels of Biodiversity – Genetic diversity, Species diversity & Ecosystem diversity.
2. Values and uses of Biodiversity.
3. Agro-biodiversity (definition and concept).
4. Causes of biodiversity loss - Loss of Genetic diversity, Loss of Species diversity, Loss of Ecosystem diversity, Loss of Agro-biodiversity.
5. Definition & concept of Sustainable Development, Goals of sustainable development.
6. Organic farming (principle, advantages, & disadvantages), Bio fertilizers (definition, examples & importance), Biofuels (definition, example, sources & importance).

Botany (Minor)
Semester-VIII
Paper - 8B (Practical)
BT- 801M

Total Marks- 40 (IA = 16 + ESE = 24)

(Credit = 1)

Sl. No	Practical	Mark
1.	Demonstration on aseptic explant preparation (from shoot tip and nodes) and aseptic inoculation of explants.	08
2.	Study of powdered drugs	08
3.	Laboratory Note book	04
4.	Viva voce	04
TOTAL		24

CONTENTS

1. Demonstration on functioning of Autoclave, pH meter, Laminar Air Flow.
2. Demonstration on sterilization technique.
3. Demonstration of aseptic inoculation technique.
4. Organoleptic and microscopic study of powdered drugs - Leaf of *Adhatoda*, Rhizome of *Zingiber*, Bark of *Alstonia*, Tuber of *Dioscoria sp.*
5. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
6. **Viva voce:** Questions based on theory and practical syllabus of 8th semester.



Tripura University

(A Central University)

Suryamaninagar

West Tripura

Syllabus for

Four Years Undergraduate Programme

Subject: Fundamental Botany

(Interdisciplinary course)

(As per NEP-2020)

Year-2023



Tripura University
(A Central University)

Course Structure of Botany (UG Programme)
As per NEP-2020 under Tripura University

FUNDAMENTAL BOTANY
(Interdisciplinary Course)

Year	Semester/ Paper code	Paper	Credits	Marks	Unit-I	Unit-II	Unit-III	Unit-IV
1 st	1 st BT-101 ID	Paper-1 Theory	3	100 (IA=40 + ESE=60)	Microbiology	Algae	Fungi & Plant Pathology	Bryophyta & Pteridophyta
2 nd	3 rd BT-301 ID	Paper-2 Theory	3	100 (IA=40 + ESE=60)	Gymnosperms & Paleobotany	Floral Morphology	Taxonomy	Economic Botany
	4 th BT-401 ID	Paper-3 Theory	3	100 (IA=40 + ESE=60)	Plant Anatomy & Ecology	Cytogenetics	Molecular Biology	Plant Physiology

**Interdisciplinary Course: Fundamental Botany
SEMESTER-I
Paper-1 (Theory)**

BT-101 ID - Microbiology & Cryptogamic Botany

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 03)

Unit-I: Microbiology

1. **Virus:** General properties of plant virus, Structure of Bacteriophage (T4 phage), Structure of RNA virus (TMV); Definition of Lytic and Lysogenic cycle.
2. **Bacteria:** General characters of bacteria; Morphological forms, Cell structure, Genetic recombination in bacteria-Transformation, Transduction and Conjugation; Economic importance of bacteria.

Unit-II: Algae

1. **Algae:** General characters, Thallus organization; Reproduction in algae – Vegetative, Asexual (spore types) and Sexual (concept of Isogamy, Anisogamy & Oogamy); Salient features of – Cyanophyceae, Chlorophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae; Economic importance of algae.

Unit-III: Fungi and Plant Pathology

1. **Fungi:** General characters including fungal mode of nutrition; Asexual spore forms and Sexual reproduction; General characters of- Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes; Economic importance of Fungi.
2. **Plant Pathology:** Definition of- Host, Pathogen, Pathogenicity, Pathogenesis, Infection, Incubation period, Inoculum, Inoculum potential, Symptom, Causal complex, Disease cycle, Endemic disease, Epidemic disease, Sporadic disease; Koch's postulates, Types of symptoms - Necrotic, Atrophic, Hypertrophic; Symptoms, Casual organisms, symptoms and Control measures of the following diseases: Late blight of Potato, Brown sport of Rice and Black stem rust of Wheat.

Unit-IV: Bryophyta and Pteridophyta

1. **Bryophyta:** General characters including amphibian nature; General idea of Life cycle of Bryophytes; Origin of Bryophytes; Distinctive features of classes – Hepaticopsida, Anthocerotopsida and Bryopsida.
2. **Pteridophyta:** Characteristic features of Pteridophytes; Concept of Homospory and Heterospory; Concept of Eusporangiate and Leptosporangiate pteridophytes; Lifecycle of Pteridophytes (general idea); General characters of the classes Psilophytopsida, Psilotopsida, Lycopsida, Sphenopsida and Pteropsida.

Interdisciplinary Course: Fundamental Botany
SEMESTER-III
Paper-2 (Theory)

BT-301 ID - Gymnosperms, Paleobotany, Taxonomy & Economic botany

Total Marks=100 (IA =40 + ESE= 60)

(Credits=03)

Unit-I: Gymnosperms and Paleobotany

1. **Gymnosperms:** General characters; Important characters of three classes- Cycadopsida, Coniferopsida, & Gnetopsida; Economic importance of Gymnosperms with reference to Wood, Resins, Essential oils, and Drugs; Distinctions and similarities between- Pteridophytes & Gymnosperms, Gymnosperms & Angiosperms; Distribution of species of *Cycas*, *Pinus* & *Gnetum* in India.
2. **Paleobotany:** Definition of Fossil; Types of fossils (Microfossil, Mega fossil and its types on the basis of nature of fossilization); Importance of fossil study; Geological time scale with dominant plant groups with ages.

Unit-II: Floral Morphology

1. **Floral morphology:** Inflorescence – Racemose & Cymose; Definition of Peduncle & Flower; Flower types, Floral parts-Calyx (types & modifications), Corolla(types & forms), Aestivation; Androecium - Stamen, Union of stamens; Gynoecium – Carpel (Apocarpous & Syncarpous), Ovary (superior & inferior), Placentation types; Process of double fertilization; Endosperm–Nuclear, Cellular and Hellobial types.

Unit-III: Taxonomy

1. **Taxonomy:** Definition of Taxonomy & Systematics, Definition of Identification, Nomenclature & Classification, Definition and example of Artificial, Natural and Phylogenetic system of classification; Principles of ICN; Herbarium and its function, Botanical Gardens and its importance; Important Herbaria and Botanical Gardens of India and world (3 each); Diagnostic characters and economically important plants of the families – Poaceae, Orchidaceae, Magnoliaceae, Solanaceae, Cucurbitaceae, Leguminosae, Compositae.

Unit-IV: Economic Botany

1. Scientific name, family, part used, and uses of following plants: **Cereal**–Rice, Wheat; **Pulses**–Moong and Lens; **Beverages**– Tea and Coffee; **Fruits**– Mango, Citrus and Papaya; **Drug yielding**–Rauwolfia, Digitalis and Andrographis; **Spices**– Ginger, Cumin and Clove; **Oil yielding**–Mustard and Groundnut; **Vegetables**–Potato, Radish and Cabbage; **Fibre yielding**– Cotton and Jute; **Timber yielding**–Teak and Sal; **Sugar yielding**– Sugarcane.
2. **Cultivation of- Rice (conventional method) and Rubber.**

Interdisciplinary Course: Fundamental Botany
SEMESTER-IV
Paper- 3 (Theory)

BT-401 ID - Anatomy, Ecology, Genetics, Molecular Biology & Plant physiology

Total Marks = 100 (IA = 40 + ESE = 60)

(Credits = 03)

Unit-I: Plant Anatomy and Ecology

1. **Plant Anatomy:** Chemical composition and gross structure of Cell wall; Meristematic tissue – Classification on the basis of position, origin and function; Simple permanent tissues – Structure, distribution and function of parenchyma, collenchyma and sclerenchyma; Cell types of Xylem and Phloem; Vascular bundle types; General anatomical characters of monocot stem and root, Dicot stem and root.
2. **Ecology:** Basic ecological concepts of-Trophic levels, Food chain, Food web, Ecological pyramids, Energy flow; Habitat and Ecological Niche; Definition of- Population, Community and Ecological succession; Adaptations of Hydrophytes, Xerophytes and Halophytes.

Unit-II: Cytogenetics

1. **Cell Biology:** Cell cycle - various phases and events, Cell division – Mitosis and Meiosis; Structure and function of cell organelles–Plasma membrane, Nucleus, Mitochondria, Chloroplast and Ribosome; Chromosome morphology, Nucleosome concept, Euchromatin and Heterochromatin.
2. **Genetics:** Mendelian genetics - Principles of segregation and independent assortment; Concept of Dominance, Incomplete dominance & Codominance; Dominant epistasis; Linkage - Definition of complete and incomplete linkage; Crossing over, Definition of Aneuploidy, Euploidy & Polyploidy.

Unit-III: Molecular Biology

1. **Molecular Biology:** Nucleoside and Nucleotide, Watson and crick model of DNA structure; Prokaryotic DNA replication (General properties), Central dogma of molecular biology, Prokaryotic Transcription, Genetic code (properties) and Translation (prokaryotic).

Unit-IV: Plant Physiology

1. Definition of water potential, osmosis, diffusion and plasmolysis; transpiration and antitranspirants.
2. **Photosynthesis:** Light reaction– PSI & PSII, Cyclic and Non-cyclic photophosphorylation; CO₂ fixation - C₃ cycle, C₄ cycle.
3. **Respiration:** Glycolysis and TCA cycle.
4. **Photoperiodism:** Photoperiodic responses and classification of plants.
5. **Physiological roles of:** IAA, Gibberellin and Cytokinin.
6. **Biological Nitrogen fixation:** Root nodule formation, role of Nitrogenase and leg haemoglobin.

SUGGESTED BOOKS AND REFERENCES

General studies

1. Ganguli, H.C., Das, K.S & Dutta, C.T. College Botany, Vol. I, latest Ed., New Central Book Agency.
2. Ganguli, H.C. and Kar, A.K. College Botany, Vol. II, latest Ed., New Central Book Agency.
3. Hait, G., Ghosh, A. and Bhattacharya, K. A Text Book of Botany (Vols. I, II & III), 2007, New Central Book Agency.
4. Lock, A.J., & Evans, D.E., Plant Biology, 2001, Viva Books.
5. Mitra, J. N., Mitra, D. and Chaudhuri, S. K. Studies in Botany (Vol-I), Moulik Library.
6. Mitra, J. N., Guha, J. and Chaudhuri, S. K. Studies in Botany (Vol-II), Moulik Library.
7. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency.
8. Uno, Storey & Moore, Principles of Botany, 2001, McGraw Hill.

Microbiology

1. Dubey, R. C. and Maheshwari, D. K. (2007), A textbook of Microbiology, S. Chand and Co., New Delhi.
2. Hogg, S. (2013), Essential Microbiology, 2nd Edition, Wiley-Blackwell.
3. Pelczar, M.J. (2001), Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
4. Prescott, L.M., Harley J.P. and Klein D. A. (2005), Microbiology, 6th Edition, McGraw Hill, India.
5. Sharma P. D. (1999), Microbiology and Plant Pathology, Rastogi Publications, Meerut, UP.

Phycology

1. Kumar, H.D. (1999), Introductory Phycology, 2nd edition, Affiliated East-West Press, Delhi.
2. Lee, R.E. (2008), Phycology, 4th edition, Cambridge University Press, Cambridge.
3. Sahoo, D. and Seckbach, J. (2016), The Algae World, Springer.
4. Sharma, O.P. (2011), Algae, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
5. Vashista B. R., Singh A.K. and Singh V.P. (2005), Botany for Degree Students-Algae, S. Chand and Co., New Delhi.

Mycology

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996), Introductory Mycology, 4th edition, John Wiley & Sons (Asia), Singapore.
2. Deacon, J. W. (2006), Fungal Biology, 4th Edition, Blackwell Publishing Ltd.
3. Sethi, I.K. and Walia, S.K. (2011), Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
4. Vashista, B. R., Singh, A.K. and Singh, V.P. (2005), Botany for Degree Students-Fungi, S. Chand and Co., New Delhi.
5. Watkinson, S. C., Boddy, L. and Money L. P. (2016), The Fungi, 3rd edition, Elsevier.
6. Webster, J. and Weber, R. (2007), Introduction to Fungi, Cambridge University Press, Cambridge.

Bryophyta

1. Parihar, N.S. Introduction to Embryophyta (Vol. 1 Bryophyta), Central Book Distributors.
2. Shaw, A. Jonathan and Goffinet Bernard, Bryophyte Biology, 2009, Cambridge University Press
3. Rashid, A. An Introduction to Bryophyta, 1998, Vikas Publishing House
4. Chopra, R.N. & Kumar, P.K. Biology of Bryophyta, Latest Ed., Wiley Eastern
5. Puri, P. Bryophyte, Latest Ed., Atmaram & Sons.
6. Vashista, B.R. Bryophyta, Latest Ed., S. Chand & Company.

Pteridophyta

1. Spore, K.R. The Morphology of Pteridophyte, Latest Ed. , Hutchinson & Co. Ltd.
2. Rashid, A. An Introduction to Pteridophyte, Latest Ed., Vani Educational Books.
3. Vashista, P.C. Pteridophyta, Latest Ed., S. Chand & Company Pvt. Ltd.
4. Gifford, E. M. & Foster, A. S. Morphology & Evolution of Vascular Plants (3rd ed.), 1998, Freeman and Co.

Gymnosperm

1. Bhatnagar, S.P. & Moitra, A. Gymnosperm, 1997, New Age International
2. Biswas, C. & Johri, P.M. The Gymnosperm, 1997, Narosa Publishing House.
3. Dutta, S.C. An Introduction to Gymnosperms (3rd ed.), 1984, Kalyani Publishers.
4. Gifford, E.M. and Foster, A.S. Morphology & Evolution of Vascular Plants (3rd ed.), 1989, Freeman & Co.
5. Karkar, R.K. & Karkar, R. The Gymnosperms, Latest Ed.
6. Sporne, K.R. The Morphology of Gymnosperms, Latest Ed., Hutchinson & Co. Ltd.
7. Vashishta, P.C. Gymnosperm, Latest Ed., S. Chand & Company Pvt.

Paleobotany & Palynology

1. Agashe, S.N. Paleobotany, Latest Ed., Oxford & IBH.
2. Bhattacharya, K., Majumdar, M.R. & Gupta Bhattacharya, S. A Text Book of Palynology, 2006, New Central Book Agency.
3. Nair, P.K. Pollen Morphology of Angiosperms, Latest Ed., Scholar Publications.
4. Shivanne, K.H. Pollen Biology & Biotechnology, 2003, Oxford & IBH.
5. Stewart, W.N. & Rothwell, G.W. Paleobotany & Evolution of Plants, Latest Ed., Cambridge University Press.
6. Thomas, B.A. & Spicer, R.A. The Evolution & Paleobotany of Land Plants, Latest Ed., Croomhelm.
7. Willis, K. J. and McElwain, J. C. The Evolution of Plants (1st Indian Ed), 2005, Oxford.

Evolution

1. Futuyma, D. J. and Kirkpatrick, M. (2017), Evolution, 4th edition, Sinauer Associates, USA.
2. Rastogi, V. B. (2018), Organic Evolution, Pub: Medtech, New Delhi.
3. Ridley, M. (2004), Evolution, 3rd edition, Blackwell Publishing.
4. Strickberger, M. W. (2000), Evolution, 3rd edition, Jones & Bartlett Publishers.
5. The Princeton Guide to Evolution (2014), Princeton University Press.

Phytopathology

1. Agrios, G.N. (1997), Plant Pathology, 4th edition, Academic Press, Cambridge, U.K.
2. Cumagun, C. J. R. (2012), Plant Pathology, In Tech, Croatia.
3. Pandey, B. P. (2001), Plant Pathology, S Chand & Co., New Delhi.
4. Sharma, P.D. (2011), Plant Pathology, Rastogi Publication, Meerut, India.
5. Strange, R. N. (2003), Introduction to Plant Pathology, Wiley-Blackwell.

Angiosperm Morphology

1. Eames, A. J. (1961), Morphology of the Angiosperms, McGraw-Hill Publication.
2. Gifford, E. M. and Foster, A. S. (1988), Morphology and Evolution of Vascular Plants, 3rd edition, W. H. Freeman and Company, New York.

Embryology

1. Bhojwani, S.S. & Bhatnagar, S.D. (1989), The Embryology of Angiosperms (4th ed.), Publishing House.
2. Lersten, N. R. (2004), Flowering Plant Embryology with Emphasis on Economic Species, Blackwell Publishing.
3. Maheshwari, P. (1950), An Introduction to the Embryology of Angiosperms, McGraw-Hill Book Company.
4. Raghavan, V. (1997), Molecular Embryology of Flowering Plants, Cambridge University Press.

Plant Anatomy

1. Beck, C. B. (2010), An Introduction to Plant Structure and Development – Plant Anatomy for the Twenty – First Century, 2nd edition, Cambridge University Press.
2. Crang, R., Sobaski, S. L. and Wise, R. (2018), Plant Anatomy – A Concept Based Approach to the Structure of Seed Plant, Springer.
3. Culter, D. F., Botha, T. and Stevenson, D. W. (2008), Plant Anatomy – An Applied Approach, Wiley-Blackwell.
4. Ewart, R. F. (2006), Esau's Plant Anatomy - Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, 3rd edition, John Wiley & Sons.
5. Fahn, A. (1974), Plant Anatomy, Pergmon Press, USA and UK.
6. Hait, G., Bhattacharya, K. and Ghosh, A.K. (2017), A Text Book of Botany, Vol-II, New Central Book Agency (P) Ltd., Kolkata.
7. Roy, P. (2010), Plant Anatomy, New Central Book Agency (P) Ltd., Kolkata.
8. Rudall, P. J. (2006), Anatomy of Flowering Plants – An Introduction to Structure and Development, Cambridge University Press.

Taxonomy

1. Heywood, V.H. Flowering Plants of the World 1978, Oxford University Press.
2. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.
3. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.
4. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill.
5. Pandey, B. P. Taxonomy of Angiosperms, 2001, S. Chand & Co, New Delhi.
6. Radford. A.B. Fundamentals of Plant Systematics, Latest Ed., Harper & Row.

7. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
8. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press.
9. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH.
10. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers.
11. Subrahmanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.
12. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House.

Plant Ecology, Biodiversity & Phytogeography

1. Ambasht, R.S. & Ambasht, N.K. A Text Book of Plant Ecology, Latest Ed., CBS Publication & Distributors.
2. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates.
3. Huggett, R. J. Fundamentals of Biogeography (2nd Ed), 2004, Routledge.
4. Krishnamurthy, K.V. An Advanced Text Book on Biodiversity, 2003, Oxford & IBH Publishing Co. Ltd.
5. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House.
6. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.
7. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders.
8. Sharma, P.D. Elements of Ecology, Latest Ed., Rastogi Publications.
9. Shukla, R.S. & Chandel, P.S. Plant Ecology, Latest Ed., S. Chand and Co.
10. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company.

Biochemistry, Plant Physiology & Plant Developmental Biology

1. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.
2. Chaudhuri, D., Kar, D.K., and Halder, S.A. Handbook of Plant Biosynthetic Pathways, 2008, New Central Book Agencies.
3. Conn, E.E. and Stumpf, R.R. Outlines of Bio-Chemistry, Latest Ed., Wiley Eastern.
4. Davies P.J. (ed.) Plant Physiology: Physiology, Bio-Chemistry & Molecular Biology, Academic Press.
5. Hall. D.O. & Rao, K.K. photosynthesis (5th ed.), 1995, Cambridge University Press.
6. Hames, B.D. Bio-Chemistry (2nd ed.) Viva Books.
7. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
8. Jain, V.K. Fundamental of Plant Physiology (7th ed.) 2004. S. Chand and Company.
9. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy. Plant Physiology and Development (6th ed.), Sinauer Associates.
10. Mehta, S.L., Lodha, M.L. & Bane, P.V. Recent Advances in Plant Biochemistry, 1989. I.C.A.R.
11. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.
12. Panday, S.N. & Sinha, B.K. Plant Physiology (4th ed.), 2006, Vikas Publishing House Pvt. Ltd.
13. Pua, E. C. and Davey, M. R. Plant Developmental Biology – Biotechnological Perspective (Vol-I), 2010, Springer.
14. Pua, E. C. and Davey, M. R. Plant Developmental Biology – Biotechnological Perspective (Vol-II), 2010, Springer.
15. Raman, H. Transport Phenomenon in Plants, 1997. Narosa Publishing House.

16. Sackheim, G. Chemistry for Biology Students (5th ed.) 1996, Benjamin/Cummings
17. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.
18. Singhal, G.S. Concepts of Photobiology: Photosynthesis & Photomorphogenesis, 1999, Narosa Publishing House.
19. Srivastava, L.M. Plant Growth and Development, 2001, Academy Press.
20. Taiz, L. & Zeiger, E. Plant Physiology (4th ed.), 2006, Sinauer Associates, Inc. Publishers.
21. Wilkins, M.B. Advances Plant Physiology. 1984, ELBS Longman.

Cell Biology, Genetics & Molecular Biology

1. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell (6th Ed), 2015, Garland Science.
2. Cooper, G.M. The Cell, A Molecular Approach (4th Ed), 2007, ASM Press.
3. Gupta, P.K. Genetics, 2007, Rastogi Publications.
4. Kar, D.K. and Halder, S. Cell Biology, Genetics and Molecular Biology 2008, New Central Book Agency.
5. Klug, W.S., Cummings, M.R., Spencer, C. A., Palladino, M. A. Concepts of Genetics (11th Ed), 2016, Pearson Education.
6. Marshall, W. and Iwasa, J. Karp's Cell and Molecular Biology (8th Ed), 2016, Wiley.
7. Pierce, Benjamin A. Genetics A Conceptual Approach (5th Ed), W.H. Freeman & Company.
8. Sen, S. & Kar, D.K. Cytology& Genetics, 2005, Narosa Publishing House.
9. Sharma, A. & Sen, S. Chromosome Botany, 2002, Oxford & IBH Publishing.
10. Snustad, D.P. & Simmons, M.J. Principles of Genetics (6th Ed), 2012, John Wiley & Sons.
11. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. Molecular Biology of the Gene (7th Ed), 2014, Pearson Education Inc.
12. Weaver, R.F. Molecular Biology (5th Ed), 2012, McGraw Hill.

Plant Tissue Culture & Biotechnology

1. Bhojwani, S.S. & Razdan, M.I. Plant Tissue Culture: Theory and Practise, 1996, Elsevier.
2. Bhojwani, S.S. & Dantu, P. K. Plant Tissue Culture: An Introductory Text, 2013, Springer.
3. Chawla, H.S. An Introduction to Plant Biotechnology (2nd Ed), 2002, Oxford & IBH.
4. Dey, K.K. Plant Tissue Culture, 1992, New Central Book Agency.
5. Dubey, R.C. Biotechnology, Latest Ed., S. Chand & Company Pvt. Ltd.
6. Gupta, P.K. Biotechnology & Genomes (latest Ed), Rastogi Publications.
7. Kar, D.K. & Halder, S. Plant Breeding, Biometry & Biotechnology, 2010, New Central Book Agency.
8. Kurnaz, I. A. Techniques in Genetic Engineering, 2015, CRC Press.
9. Nair, A. J. Introduction to Biotechnology and Genetic Engineering, 2007, INFINITY SCIENCE PRESS LLC.
10. Razdan, M.K. An Introduction to Plant Tissue Culture, Latest Ed., Oxford & IBH.
11. Singh, B.D. Biotechnology Latest ed., Kalyani Publishers.
12. Slatter, A., Scott, N. & Fowler, N. Plant Biotechnology, 2003, Oxford University Press.
13. Walker, J.M. & Rapley, R. Molecular Biology & Biotechnology, 2000, Royal Society of Chemistry Publishing House.
14. Wilson and Walker's Principles and Techniques of BIOCHEMISTRY AND MOLECULAR BIOLOGY (8th Ed), Cambridge.

Economic Botany

1. Pandey, B. P. Economic Botany (6th Ed), 2005, S. Chand & Co.
2. Wickens, G. E. Economic Botany – Principles and Practices, 2001, Springer.

Plant Breeding & Biometry

1. Allard, R.W. Principles of Plant Breeding, 1960, John Wiley & Sons.
2. Brown, J. and Caligari, P. D. S. An Introduction to Plant Breeding, 2008, Blackwell Pub.
3. Chaudhuri, H.K. Elementary Principles of Plant Breeding, Latest Ed., Oxford & IBH.
4. Dutta, A. K. Basic Biostatistics & Its Application, 2006, New Central Book Agency.
5. Kar, D.K. and Halder, S. Plant Breeding & Biometry, 2006, New Central Book Agency.
6. Le, C. T. Introductory Biostatistics, 2003, John Wiley & Sons.
7. Roy, D. Plant Breeding: Analysis & Exploitation of Variation, 2000, Narosa Publishing House.
8. Singh, B.D. Plant Breeding, Principles & Methods (7th ed.), 2005, Kalyani Publishers.
9. Spiegel, M. R. And Stephens, L. J. Schaum's Outlines Statistics, (4th Ed), McGraw-Hill.

Horticulture & Floriculture

1. Acquaah, G. Horticulture – Principles and Practices (4th Ed), 2009, Pearson.
2. Adams, C. R., Bamford, K. M. and Early, M. P. Principles of Horticulture, (5th Ed), 2008, Elsevier.
3. Randhawa, G. S. Floriculture In India, 2010, Allied Publishers.
4. Sadhu, M. K. Plant Propagation, 2005, New Age International Publishers.

Pharmacognosy

1. Kokate, C. K., Purohit, A. P. and Gokhale, S. B. Pharmacognosy (48th Ed), 2013, Nirali Prakashan.
2. Shah, B. and Seth, A. K. Text Book of Pharmacognosy & Phytochemistry (1st Ed), 2010, Elsevier.
3. Trease & Evans, Pharmacognosy (16th Ed), 2009, Saunders.

Ethnobotany

1. Awasthi, A. K. The Concepts of Ethnobotany, Ane Books Pvt. Ltd.
2. Trivedi, P. C. Medicinal Plants: Ethnobotanical Approach, 2006, Agrobios, India.
3. Purohit & Vyas, Medicinal Plant Cultivation: A scientific Approach (2nd Ed), 2008, Agrobios, India.
4. Saroya, A. S. Ethnobotany, ICAR.

Industrial Microbiology, Algal Biotechnology & Applied Mycology

1. Bux, F. and Chisti, U. Algae Biotechnology – Products and Processes, 2016, Springer.
2. Deacon, J. W. Fungal Biology (4th Ed), 2006, Blackwell Publishing Ltd.
3. Kavanagh, K. Fungi – Biology and Application, 2005, Wiley.

4. Okafor, N. and Okeke, B. C. Modern Industrial Microbiology and Biotechnology (2nd Ed), 2018, Taylor & Francis.
5. Saxena, S. Applied Microbiology, 2015, Springer.
6. Waites, M. J., Morgan, N. L., Rockey, J. S. and Highton, G. Industrial Microbiology: An Introduction, 2001, Blackwell.

Analytical Techniques

1. Bell, S. and Morris, K. An Introduction to Microscopy, 2010, CRC Press.
2. Exbrayat, J. M. Histochemical and Cytochemical Methods of Visualization, 2013, CRC Press.
3. Horobin, R. W. Histochemistry: An explanatory outline of histochemistry and biophysical staining, 1982, Butterworths.
4. Katoch, R. Analytical Techniques in Biochemistry and Molecular Biology, 2011, Springer.

Environmental Botany

1. Ambasht, R.S. (2000), A text Book of Plant Ecology, 3rd edition, Students, Friends 7 co., Varanasi.
2. Dash, M.C. and Das, S. P. (2009), Fundamentals of Ecology, Tata McGraw Hill publishing Company Ltd, New Delhi.
3. Purohit, S.S., Shammi, Q.J. and Agarwal, A.K. (2004), A Textbook of Environmental Science, students Edition, Jodhpur.
4. Santra, S.C. (2013), Environmental Science, 3rd edition, New Central Book Agency (P) Ltd., Kolkata.
5. Sharma, P.D. (2004), Ecology and Environment, 7th edition, Rastogi publication, Meerut.
6. Verma, P.S. and Agarwal, V.K. (2005), Environmental Biology-Principles of Ecology, S. Chand & co Ltd, New Delhi.

Research Methodology

1. Singh, Y. K. (2006) Fundamentals of Research Methodology and Statistics, New Age Intl.
2. Jha. N. et. al. (2013) Research Methodology, 1st Edition, Himalaya Publishing House.
3. Pandey, P. and Pandey, M. M. (2015) Research Methodology: Tools and Techniques, Bridge Center.
4. Kothari, C. R. (1990) Research Methodology: Methods and Techniques, 2nd Revised Edition, New Age Intl.

Intellectual Property Rights (IPR)

1. Ahuja, V. K. 2017, Law Relating to Intellectual Property Rights, 3rd edition, Lexis Nexis.
2. Tewari, R. and Bhardwaj, M. 2021, Intellectual Property – A Primer for Academia, Publication Bureau, Punjab University.
3. Wadehra, B. L. 2016, Law Relating to Intellectual Property, 5th edition, Universal law Publishing Co.

Computer Fundamentals

1. Computer Knowledge, 2nd edition, Disha publication.
2. Salaria, R. S. 2022, Fundamentals of Computer and Information Technology – A Gateway to Computer Literacy, 1st edition, Khanna Publishers.

3. Thareja, R. 2019, Fundamentals of Computer, 2nd edition, Oxford.

Bioinformatics

1. Ghosh, Z, and Mallik, B. 2008, Bioinformatics Principles and Applications. Oxford University Press, New Delhi.
2. Kar, D.K. and Halder, S. 2009, Cell Biology Genetics Molecular Biology. New Central Book Agency (P) Ltd., Kolkata.
3. Letovsky, S.I. 1999, Bioinformatics. Kluwer Academic Publishers.
4. Rashidi and Buchler, 2000, Bioinformatics Basics. CRC Press
5. Rastogi et al 2003, Bioinformatics: Concepts, Skills and Applications. CBS
6. Singh, B.D. 2004, Biotechnology Expanding Horizons. Kalyani Publishers, New Delhi.
