



# **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 <sup>st</sup>	1 <sup>st</sup> BT101C	Paper-1 Theory	4	100 (IA=40 + ESE=60)	Microbiology-I	Microbiology-II	Phycology-I	Phycology-II
		Paper-2A Theory	2	60 (IA=24 + ESE=36)	Mycology-I	Mycology-II	Mycology-III	Lichen, Myxomycetes & Mycorrhiza
	BT102C		Paper-2B Practical	2	40 (IA=16 + ESE=24)	<i>Based on Theory paper 1 &amp; 2A</i>		
	2 <sup>nd</sup> BT103C	Paper-3 Theory	4	100 (IA=40 + ESE=60)	Bryophyta	Pteridophyta	Gymnosperms	Basic Paleobotanical Principles
	2 <sup>nd</sup> BT104C	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)	<i>Based on Theory paper 3 &amp; 4A</i>			
2 <sup>nd</sup>	3 <sup>rd</sup> BT201C	Paper-5 Theory	4	100 (IA=40 + ESE=60)	Elementary Phytopathology	Angiosperm Morphology	Plant anatomy	Embryology
		Paper-6A Theory	2	60 (IA=24 + ESE=36)	Taxonomy-I	Taxonomy-II	Monocot Families	Dicot Families
	BT202C		Paper 6B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory paper 5 &amp; 6A</i>		
	4 <sup>th</sup> BT203C	Paper-7 Theory	4	100 (IA=40 + ESE=60)	Plant Ecology-I	Plant Ecology- II	Natural Resource Management & Sustainable Development	Phyto- geography
	4 <sup>th</sup> BT204C	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)	<i>Based on theory paper 7 &amp; 8A</i>			
3 <sup>rd</sup>	5 <sup>th</sup> BT-301C	Paper-9 Theory	4	100 (IA=40 + ESE=60)	Cell biology-I	Cell Biology-II	Plant Physiology-I	Plant Physiology-II
		Paper-10A Theory	2	60 (IA=24 + ESE=36)	Genetics-I	Genetics-II	Genetics-III	Genetics-IV
	BT302C		Paper 10B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory paper 9 &amp; 10A</i>		
	5 <sup>th</sup> BT303C	Paper-11 Theory	4	100 (IA=40 + ESE=60)	Molecular Biology-I	Molecular Biology-II	Molecular Biology-III	Plant Biotechnology- I
	5 <sup>th</sup> BT304C	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	<i>Based on theory paper 11 &amp; 12A</i>			

		Practicals		(IA=16 + ESE=24)				
	<b>6<sup>th</sup> BT305C</b>	Paper-13 Theory	4	100 (IA=40 + ESE=60)	Plant Breeding	Biometry	Horticultural Practices-I	Horticultural Practices-II
	<b>6<sup>th</sup> BT306C</b>	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 &amp; 14A</i>			
	<b>6<sup>th</sup> BT307C</b>	Paper-15 Theory	4	100 (IA=40 + ESE=60)	Industrial and Applied Microbiology-I	Industrial and Applied Microbiology-II	Algal Biotechnology	Applied Mycology
	<b>6<sup>th</sup> BT308C</b>	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 &amp; 16A</i>			
<b>4<sup>th</sup></b>	<b>7<sup>th</sup> BT401C</b>	Paper-17 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	<b>7<sup>th</sup> BT402C</b>	Paper-18A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper 18B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 17 &amp; 18A</i>			
	<b>7<sup>th</sup> BT403C</b>	Paper-19 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	<b>7<sup>th</sup> BT404C</b>	Paper-20A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-20B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 19 &amp; 20A</i>			
	<b>8<sup>th</sup> BT405C</b>	Paper-21 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	<b>8<sup>th</sup> BT406C</b>	Paper-22A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-22B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 21 &amp; 22A</i>			
	<b>8<sup>th</sup> BT407C</b>	Paper-23 Theory	4	100 (IA=40 + ESE=60)	*	*	*	*
	<b>8<sup>th</sup> BT408C</b>	Paper-24A Theory	2	60 (IA=24 + ESE=36)	*	*		
		Paper-24B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 23 &amp; 24A</i>			

**\*Has been added after 3<sup>rd</sup> year (6<sup>th</sup> semester)**

**DETAILED COURSE CONTENT OF  
BOTANY MAJOR**

**1<sup>st</sup> YEAR**

**Botany (Major)**

**SEMESTER-I**

**Paper- 1 (Theory)**

**BT-101C- Microbiology & Phycology**

**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, Chlamydozoospores & 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, Zygozoospores & 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.	<i>Viva voce</i>	02
<b>TOTAL</b>		<b>24</b>

**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 1<sup>st</sup> semester.



## Botany (Major)

### SEMESTER-II

#### Paper-3 (Theory)

#### BT-103C- 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 (Phyllum: Marchantiophyta), Hornworts (Phyllum: Anthocerotophyta), and Mosses (Phyllum: 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-104C- 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. *Cordaites*
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-104C**

**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.	<i>Viva voce</i>	03
<b>TOTAL</b>		<b>24</b>

**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 2<sup>nd</sup> semester.

## **2<sup>ND</sup> YEAR**

### **Botany (Major)**

### **SEMESTER-III**

### **Paper- 5 (Theory)**

### **BT-201C- 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-II: 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 & Helobial types.
8. Polyembryoni (definition and types) and Apomixis (types).

**Botany (Major)**  
**SEMESTER-III**  
**Paper- 6A (Theory)**  
**BT-202C- 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-202C**

**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
5.	Laboratory Note book	02
6.	<i>Viva voce</i>	02
<b>TOTAL</b>		<b>24</b>

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 3<sup>rd</sup> semester.

**Botany (Major)**

**SEMESTER-IV**

**Paper-7 (Theory)**

**BT-203C- 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, 1960).
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-204C- 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 ( $\Delta G^\circ$ ), Endergonic and Exergonic reaction.
2. Coupled reaction, ATP structure and importance.
3. Importance of NADH, NADPH & FADH<sub>2</sub>.
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 ( $\alpha$  helix,  $\beta$ -sheet &  $\beta$ -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-204C**

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

**(Credits = 02)**

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

- 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 4<sup>th</sup> semester.

**3<sup>rd</sup> YEAR**

**Botany (Major)**

**SEMESTER-V**

**Paper-9 (Theory)**

**BT-301C- Cell Biology & Plant Physiology**

**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. C<sub>3</sub> cycle, C<sub>4</sub> 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 Abscisic 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-302C- 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-302C**

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

**(Credits = 02)**

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

- 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:**
  - 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.
- 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-303C- 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-304C- 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,  $\lambda$ -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-304C**

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

**(Credits = 02)**

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

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-305C- 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-306C- 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-306C**

**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.	<i>Viva voce</i>	02
<b>TOTAL</b>		<b>24</b>

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-307C- 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 –  $\beta$ -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-308C- 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 Stratiography, 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,  $\alpha$ -diversity,  $\beta$ -diversity &  $\gamma$ -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- 308C**

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

**(Credits = 02)**

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

1. Study of pollen sterility & fertility by acetocarmine staining.
2. Study of Plant community parameters (Frequency, Density, Abundance & Relative abundance) from vegetation map by Quadrata 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 Botany Major 4<sup>th</sup> Year  
(As per NEP-2020 under Tripura University)**

**Botany Major (4<sup>th</sup> YEAR)**

Year	Semester	Paper	Credits	Mark	Unit - I	Unit - II	Unit-III	Unit-IV
4 <sup>th</sup>	7 <sup>th</sup>	Paper-17 Theory	4	100 (IA=40 + ESE=60)	Advanced Cryptogamic Botany-I	Advanced Cryptogamic Botany-II	Fungal Biology	Modern Plant Pathology - I
		7 <sup>th</sup>	Paper-18A Theory	2	60 (IA=24 + ESE=36)	Modern Plant Pathology - II	Modern Plant Pathology - III	Plant Secondary Metabolism-I
	7 <sup>th</sup>		Paper 18B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 17 &amp; 18A</i>		
	7 <sup>th</sup>	Paper-19 Theory	4	100 (IA=40 + ESE=60)	Advanced Plant Anatomy - I	Advanced Plant Anatomy - II	Modern Plant Taxonomy	Angiosperm Evolution
	7 <sup>th</sup>	Paper-20A Theory	2	60 (IA=24 + ESE=36)	Pollination Biology	Plant- Plant & Plant-Animal Interaction	Research Methodology-I	Research Methodology-II
		7 <sup>th</sup>	Paper-20B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 19 &amp; 20A</i>		
	8 <sup>th</sup>	Paper-21 Theory	4	100 (IA=40 + ESE=60)	Advanced Cell & Molecular Biology-I	Advanced Cell & Molecular Biology-II	Analytical Techniques - I	Analytical Techniques - II
	8 <sup>th</sup>	Paper-22A Theory	2	60 (IA=24 + ESE=36)	Applied Biotechnology-I	Applied Biotechnology- II	Environmental Botany-I	Environmental Botany-II
		8 <sup>th</sup>	Paper-22B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 21 &amp; 22A</i>		
	8 <sup>th</sup>	Paper-23 Theory	4	100 (IA=40 + ESE=60)	Advanced Plant Physiology – I	Advanced Plant Physiology – II	Stress Physiology	Plant Developmental Biology
	8 <sup>th</sup>	Paper-24A Theory	2	60 (IA=24 + ESE=36)	Intellectual Property Rights	Computer Fundamentals	Bioinformatics- I	Bioinformatics- II
		8 <sup>th</sup>	Paper-24B Practicals	2	40 (IA=16 + ESE=24)	<i>Based on theory papers 23 &amp; 24A</i>		



**4<sup>th</sup> YEAR**

**Botany (Major)**

**SEMESTER-VII**

**Paper- 17 (Theory)**

**BT401C – Advanced Cryptogamic Botany, Fungal Biology & Modern Plant Pathology-I**

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

**Credit = 04**

**Unit-I (Advanced Cryptogamic Botany-I)**

1. Ultra structure of flagella in Algae.
2. Algal chloroplast - origin, ultra structure and evolution of chloroplast structure.
3. Algal sexuality – (i) Origin and evolution of sex in Algae, (ii) Regulation of mating types in algae (*Chlamydomonas reinhardtii*).
4. Cyanophyta – (i) Akinets & Heterocysts (structure, formation and function), (ii) N<sub>2</sub> fixation in BG algae, (iii) Complementary Chromatic Adaptation, (iv) Cyanotoxins – Types with examples and importance.
5. Chlorophyta – (i) Structure of Flagellar apparatus, (ii) Algal phototaxis – Eye spot & phototactic movement in green algae, (iii) Origin of green algae - Evolutionary significance of *Prochloron*, (iv) Affinity of Chlorophyta.
6. Dinophyta – General characters, Cell structure, Bioluminescence in dinoflagellates.

**Unit-II (Advanced Cryptogamic Botany-II)**

1. Origin of Bryophyta (Algal origin and Pteridophytic origin) & Affinities of Bryophyta.
2. Alternation of generations in Bryophyta – Homologous theory and Antithetic theory.
3. Evolution of gametophyte (progressive & retrogressive theories) and sporophyte (theory of progressive sterilization & theory of reduction) in Bryophyta.
4. Spore dispersal mechanism in Bryophytes.
5. Ecological physiology – mechanism of desiccation tolerance in bryophytes.
6. Changes in plant life for land adaptation.
7. Origin of land plants (Telome concept).
8. Enation theory and origin of microphylls.
9. Heterospory (definition & significance) and origin of seed habit.

### **Unit-III (Fungal Biology)**

1. Fungal cell wall - Composition, architecture, & synthesis.
2. Mechanism of fungal growth – Budding in yeast and tip growth in filamentous fungi.
3. Fungal sexuality - Degeneration of sex in Fungi.
4. Homothallism & Heterothallism and its genetic control.
5. Regulation of mating system in fungi (Example – *Saccharomyces cerevisiae*, *Neurospora crassa*).
6. Parasexuality – Stages of parasexual cycle and its significance.
7. Fungal endophytes – Definition & importance (role in plant defence and production of bioactive compounds).
8. Fungi in ecosystem – Important ecological role of fungi in soil formation, nutrient cycling & biodegradation.

### **Unit-IV (Modern Plant Pathology-I)**

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. Disease development in plant - Role of enzymes and toxins in disease development.
3. Physiology of diseased plants - Effects of diseases on physiological parameters (Photosynthesis, Respiration, Protein synthesis, Nuclie acid metabolism & Phenol metabolism).
4. Factors responsible for disease development – Host resistance, Genetic uniformity of host, Type of crop, Age of Host, Virulence of pathogen, Quantity of inoculum, Mode of pathogen spread, Moisture content & Temperature.
5. Role of pathogenicity genes in plant disease development.

**Botany (Major)**

**SEMESTER-VII**

**Paper-18A (Theory)**

**BT402C – Modern Plant Pathology-II, III & Plant Secondary Metabolism**

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

**Credit = 02**

**Unit-I (Modern Plant Pathology-II)**

1. Plant Defence system – Non Host resistance, Horizontal resistance & Vertical resistance, Role of R-gene in resistance.
2. Pre-existing structural defence in plants.
3. Pre-existing chemical defence in plants.
4. Induced structural defence in plants – Cell wall defence structure, Formation of cork layer, Formation of abscission layer, Formation of tyloses, Deposition of gums.
5. Necrotic structural defence - Hypersensitive reaction.

**Unit-II (Modern Plant Pathology-III)**

1. Induced biochemical defence in plants – Role of pathogenesis related proteins, Phenolics & Phytoalexins.
2. Role of 'avr' genes in plant disease resistance.
3. Definition of 'Systemic Acquired Resistance' (SAR) & 'Induced Systemic Resistance' (ISR).
4. Defence elicitors – Definition of defence elicitors and types with example (Abiotic and Biotic).
5. Role of Salicylic acid and Methyl jasmonate on plant defence.

**Unit-III (Plant Secondary Metabolism-I)**

1. Definition of Secondary metabolites & difference between primary and secondary metabolites.
2. Role (Functions) of following secondary metabolites in plant - Flavonoids, Anthocyanines, Tannins, Lignins, Suberins & Cyanogenic glycosides.
3. Alkaloids – Major classes with their amino acid precursor and example.
4. Types of glycosides – O-glycoside, N-glycoside, S-glycoside & C-glycoside.
5. Biosynthetic pathways of important secondary metabolites – Terpenoid biosynthesis (Mevalonate pathway & MEP pathway), Phenylpropanoid biosynthesis (Shikimic acid pathway).
6. Formation of Lignins, Tannins and Carotenoids.

## **Unit-IV (Plant Secondary Metabolism-II)**

1. Major types of secondary metabolites with source plants and human use:
  - i. Alkaloids – Nicotine, Atropine, Reserpine, Cocaine, Colchicine.
  - ii. Glycosides – Digitoxin, Chiratin, Glycyrrhizine, Amygdalin.
2. Health benefits of phenolic compounds and source and uses of following phenolics - Caffeic acid, Coumaric acid, Gallic acid, Ferulic acid, & Rosmarinic acid.
3. Source and use (with example) of flavonoids as anticancer drug, antioxidant & cardio protective drug.
4. Tannins (tannic acid) – Source and health benefits (with example).
5. Anthocyanines – Health benefits.
6. Source and use of following essential oils – Peppermint, Eucalyptus, Lemon, Rosemary & Lavender.

**Botany (Major)**  
**SEMESTER-VII**  
**Paper-18B (Practicals)**  
**BT402C**

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

**Credit = 02**

Sl. No.	Practical	Marks
1.	Workout on Algae	07
2.	Workout on Fungi	07
3.	Histological study of plant diseases through hand sectioning. OR Demonstration of isolation of pathogenic fungus from diseased plant part. OR Biochemical detection of secondary metabolites	04
4.	Laboratory Note book	03
5.	<i>Viva voce</i>	03
<b>TOTAL</b>		<b>24</b>

**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, Chara, Vaucheria, Ectocarpus, Polysiphonia*
2. Workout on fungal specimens with measurement of reproductive structures, free hand drawing, and identification of genus with identifying characters - *Ascobolus, Puccinia, Agaricus*
3. Histological study of plant diseases through hand sectioning and identification of the disease - Tikka disease of ground nut, Red rot of sugarcane, Brown spot of rice, Black stem rust of wheat (*Puccinia* from *Justicia* leaf).
4. Demonstration of isolation of pathogenic fungus from diseased plant part.
5. Biochemical detection of secondary metabolites – Alkaloids & Phenol
6. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
7. Viva voce based on theory and practical syllabus of Paper 17 & 18A.

**Botany (Major)**  
**SEMESTER-VII**  
**Paper- 19 (Theory)**

**BT403C - Advanced Plant Anatomy, Modern Plant Taxonomy & Angiosperm Evolution**

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

**Credit = 04**

**Unit-I (Advanced Plant Anatomy – I)**

1. Plant Cell Wall – Origin of cell wall during cell division, Growth and expansion of cell wall.
2. Epidermal tissue – Trichomes (types and functions), Epicuticular waxes – Nature and functions.
3. Mechanical tissues – Functions and the principles governing their distribution in plants.
4. Ontogeny and differentiation of Xylem vessels and Sieve tubes.
5. Organisation of shoot apex (Tunica–Corpus) and Root apex (Körper-Kappe) in angiosperms.
6. Root-stem transition.
7. Bark anatomy – Characters and formation of Periderm, Rhytidome, Lenticels, Polyderm, Ring bark & Scale bark.

**Unit-II (Advanced Plant Anatomy – II)**

1. Wood anatomy – Formation of wood, Soft wood & Hard wood, Sap wood & Heart wood.
2. Characters of Gymnospermous (Coniferous) wood & Angiospermous (Dicot) wood.
3. Vascular cambium – Structure (Fusiform & Ray initials, Storied & Non-storied cambium).
4. Anomalous secondary growth – Stems of *Boerhaavia*, *Mirabilis*, *Bignonia*, *Nyctanthes* & *Chenopodium*
5. Nodal anatomy – Types.
6. Applications of plant anatomy in Systematics, Forensics and Pharmacognosy.

**Unit-III (Modern Plant Taxonomy)**

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
3. Chemotaxonomy – (i) Definition, Important characters used in Chemotaxonomy, and Importance of Chemotaxonomy (explanation with examples), (ii) Serotaxonomy (definition).
4. Cytotaxonomy – Definition, Important characters used in Cytotaxonomy, Importance of Cytotaxonomy (explanation with examples).
5. Numerical taxonomy (Phenetics) – Definition, Principle, Steps, Advantages & Disadvantages.
6. 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) Polyotomy & Reticulation.

#### **Unit-IV (Angiosperm Evolution)**

1. Brief idea about major evolutionary forces - Mutation, Migration, Selection & Genetic drift.
2. Defining angiosperms – Unifying characters of angiosperms.
3. Origin and phylogeny of Angiosperms – different theories.
4. Basal living Angiosperms and concept of Paleoherbs.
5. Origin and structural evolution of stamen in angiosperms.
6. Structural evolution of pollen grains.
7. Origin and structural evolution of carpel and ovule in angiosperms.
8. Evolution of placentation types.

**Botany (Major)**  
**SEMESTER-VII**  
**Paper-20A (Theory)**

**BT404C – Pollination Biology, Plant Animal Interaction & Research Methodology**

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

**Credit = 02**

**Unit-I (Pollination Biology)**

1. Pollination types- Self pollination & Cross pollination (definition, advantages / disadvantages).
2. Contrivances for self pollination.
3. Contrivances of cross pollination.
4. Self Incompatibility – Heteromorphic system & Homomorphic system (Gametophytic & Sporophytic systems), Methods of overcoming self incompatibility.
5. Male sterility (definition, types, importance in plant breeding).
6. Major types of pollinating agents: Pollination syndrome (definition), Traits of flowers pollinated by Water, Air, Bee, Butterfly, Fly, Bird and Bat.
7. Mechanism for pollen reception, pollen tube growth and discharge of male nuclei.
8. Major floral reward for pollinator – Nectar (definition and constituents).
9. Pollinator crisis – Definition, Factors responsible for Pollinator crisis.

**Unit-II (Plant-Plant & Plant-Animal Interaction)**

1. Types of Plant-animal interactions (explanation with examples) – (i) Mutualism, (ii) Antagonism – Herbivory (Monophagous & Polyphagous), Insectivory, & Parasitism, (iii) Commensalism.
2. Effect of herbivory on plants and community structure.
3. Plant's defence mechanism against herbivory.
4. Controlling herbivores – various techniques of pest control.
5. Effect of parasitism on natural population and community – explanation with example.
6. Coevolutionary relationship between Plant & insect pollinator – Explanation with examples & significance.
7. Plant-Plant Interaction – Facilitation, Competition, Allelopathy & Parasitism (explanation with examples).



### **Unit-III (Research Methodology-I)**

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.
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 (formal write-up of conclusions reached).

### **Unit-IV (Research Methodology-II)**

1. Formulation of research problem: Factors affecting the selection of research problem – (Types of Internal & External factors).
2. 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.
3. Types of sampling – Probability sampling (Simple random sample, Stratified random sample, Cluster sample), Non-probability sampling (Quota sampling, Purposive sampling, Convenience sampling, Snowball sampling).
4. Hypothesis – Features of good hypothesis, Types of hypothesis – Descriptive, Relational, Explanatory, Null hypothesis, Alternative.
5. Variables – Types of variables (Continuous & Discrete, Dependable & Independent Extraneous variable).
6. Data – Primary data & Secondary data; Methods of data collection (Observation, Personal interview, Telephonic interview, Mailed questionnaires, Schedules).
7. Report writing – General layout of report.
8. Bibliography & Reference (definition & difference).
9. Important features of Seminar, Workshop, Symposium, & Conference.

**Botany (Major)**  
**SEMESTER-VII**  
**Paper-20B (Practicals)**

**BT404C**

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

**Credit = 02**

<b>Sl. No.</b>	<b>Practical</b>	<b>Marks</b>
<b>1.</b>	Study of Anomalous secondary structures with double staining. OR Study of Nodal anatomy. OR Study of xylem vessels by maceration technique.	<b>07</b>
<b>2.</b>	Workout on Angiospermic plants.	<b>09</b>
<b>3</b>	Study of in vitro pollen germination.	<b>04</b>
<b>4.</b>	Laboratory Note book	<b>02</b>
<b>5.</b>	<i>Viva voce</i>	<b>02</b>
<b>TOTAL</b>		<b>24</b>

**CONTENTS:**

1. Study of Anomalous secondary structures with double staining and preparation of permanent slides -  
Stem of: *Boerhaavia sp.*, *Bignonia sp.*, *Chenopodium sp.*, *Nyctanthes sp.*
2. Study of Nodal anatomy freshly prepared slide/permanent slide – Unilacunar, Trilacunar, Multilacunar.
3. Study of xylem vessels by maceration technique from *Cucurbita* stem.
4. Workout on Angiospermic plants: Flower dissection, diagram of plant parts, description of plant, Floral formula, Floral diagram, identification up to Species level with the help of suitable literature from the families: Solanaceae, Malvaceae, Rubiaceae, Asteraceae, Lamiaceae.
5. Study of in vitro pollen germination.
6. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
7. Viva voce based on theory and practical syllabus of Paper 19 & 20A.

**Botany (Major)**

**SEMESTER-VIII**

**Ppaper-21 (Theory)**

**BT405C – Advanced Cell and Molecular Biology & Analytical Techniques**

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

**Credit = 04**

**Unit-I (Advanced Cell & Molecular Biology-I)**

1. Plasma membrane – Types of transport proteins in plasma membrane.
2. Ribosome – Biogenesis and assembly.
3. Cytoskeleton – Structure and functions of Microtubules, Microfilaments, and Intermediate filaments.
4. Eukaryotic DNA replication – Mechanism and role of different protein factors.
5. Transcription in Eukaryotes – Types of RNA polymerases in eukaryotes; Transcription initiation by RNA polymerase II.
6. Eukaryotic pre mRNA processing – mechanism of capping on the 5' end, polyadenylation of the 3' end and pre-mRNA splicing.

**Unit-II (Advanced Cell & Molecular Biology-II)**

1. Transcriptional regulation of gene activity in Eukaryotes – Important regulatory sequences (TATA box & Enhancers) and role of Activators and Repressor proteins.
2. Gene silencing – brief idea (detailed mechanism not required).
3. Cell signalling – (i) Types of receptors (cell surface receptor & intracellular receptor), (ii) Mechanism of G protein linked receptors, (iii) Secondary messenger – Definition and role of cAMP, Ca, IP3 and DAG as second messenger.
4. Apoptosis and cell death – Definition & pathways (intrinsic & extrinsic).
5. Cancer cells – (i) Properties of cancer cells, (ii) Origin of cancer cells – (a) activation of proto-oncogenes, (b) loss of tumour suppressor activity and (c) role of virus infection.
6. Karyotype concept – Definition of Karyotype, Karyogram & Idiogram; Symmetrical & Asymmetrical Karyotype, Definition of Basic number.

### **Unit-III (Analytical Techniques-I)**

- 1. Stains and staining:** Objective of staining, Distinction between Stain & Dye, Dyes – Natural & Synthetic (examples), Structural components (nature) of stains (concept of Chromophore & Auxochrome), Mordants, Accentuators & Leuco compounds (definition), Mechanism of Staining, Metachromasia, Types of staining – Simple staining (Direct & Indirect staining) & Differential staining, Progressive staining, Regressive staining, Vital staining
- 2. Microscopy:** Microscopy – Concept of magnification, resolution, and contrast; Brief idea of types of microscopes – Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Polarized light microscopy, Fluorescent microscopy, Confocal microscopy, TEM & SEM, Flow Cytometry (principle)
- 3. Chromatography:** General principle, Types (principle and use) - Paper chromatography, Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography, Affinity chromatography, Hydrophobic interaction chromatography, Gel Filtration chromatography.
- 4. Radiometric dating:** Basic principles of C14 dating.

### **Unit-IV (Analytical Techniques-II)**

- 1. Centrifugation:** General principles (concept of sedimentation coefficient), Differential and Density gradient centrifugation, Isopycnic centrifugation, Analytical centrifugation, Ultracentrifugation
- 2. Spectrophotometry:** General principle – Distinction between Photometer, Spectrophotometer (Single Beam & Double Beam), and Colorimeter; Definition of Absorbance, Transmittance, Optical density, and Relative transmittance; Beer law, Lambert law, UV-Vis Spectroscopy
- 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.
- 4. Blotting** – Basic techniques of Northern, Southern & Western blotting.

**Botany (Major)**

**SEMESTER-VIII**

**Paper-22A (Theory)**

**BT406C – Applied Biotechnology & Environmental Botany**

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

**Credit = 02**

**-I (Applied Biotechnology-I)**

1. Expression vectors – Definition and example (pGEX)
2. Protein Expression system: Components of *E. coli* expression system.
3. Downstream processing and product recovery –
  - i. Solid liquid separation (Flotation, Flocculation, Filtration & Centrifugation).
  - ii. Release of intracellular products (Physical, Chemical & Enzymatic cell disruption methods).
  - iii. Concentration (Evaporation, Liquid-liquid extraction, Membrane filtration, Precipitation & Adsorption).
  - iv. Purification (Chromatography).
  - v. Formulation (Drying, Spray drying & Lyophilization).

**Unit-II (Applied Biotechnology-II)**

1. Pest resistant plant - Bt-cotton (Basic concept).
2. Herbicide resistant plants - Round up Ready soybean.
3. Transgenic crops with improved quality traits - Flavour Savour tomato, Golden rice.
4. Improved horticultural varieties - Moon dust carnations.
5. Role of transgenics in bioremediation - Superbug.
6. Edible vaccines (definition and example).
7. Industrial enzymes (Aspergillase, Protease, Lipase) – Source & application.
8. Genetically Engineered Products - Human Growth Hormone; Humulin.
9. Production of secondary metabolites through Plant Tissue Culture system (including Hairy root culture).

### **Unit-III (Environmental Botany-I)**

1. Structure of atmosphere (layers of atmosphere), Hydrosphere and Lithosphere, Structural characteristics of earth (Core, Mantle & Crust).
2. **Pollution:** (i) Definition and types of pollutants, (ii) Major air pollutants and their sources, control measures, (iii) Effects of Air pollution on plants and animals, (iv) Control measures of air pollution, (v) Water pollution and Land pollution – Causes and effects, (vi) Noise pollution- Source, effects and remedial measures, (vii) Heavy metal pollution – Sources and effects of heavy metal pollution.
3. **Environmental Problems** – (i) Basic concept of Green House Effect and Global Warming (including major GH gases and their source & concept of ‘Global Warming Potential’), (ii) Acid rain-Definition, mechanism of formation and effects, (iii) Smog – Concept of classical and Photochemical smog, mechanism of formation of photochemical smog, (iv) Brief idea of La-Nina and El-Nino, (v) Ozone umbrella and Ozone hole - Types of ozone depleting chemicals and their interactions, (vi) Eutrophication.

### **Unit-4 (Environmental Botany-II)**

1. Definition of Bio-entry, Bioaccumulation, Biotransformation and Biomagnification.
2. **Phytoremediation** – Definition, application and advantages.
3. **Carbon credit** – Concept and exchange of carbon credits.
4. **Carbon sequestration** - Meaning and importance.
5. **Salient features of important environmental conventions, agreement and protocols** – RAMSAR Convention (1971), Montreal Protocol (1987), Convention on Biological Diversity (1992), Earth Summit (1992), Kyoto Protocol (1997), and Paris agreement (2016).
6. **Salient features of Environment protection acts in India** - Wild life protection act 1972, Forest conservation act 1980, National Environmental Policy -2006.
7. **Environmental movements** - Chipko movement and Silent Valley movement.

**Botany (Major)**

**SEMESTER-VIII**

**Paper-22B (Practicals)**

**BT406C**

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

**Credit = 02**

<b>Sl. No.</b>	<b>Practical</b>	<b>Marks</b>
<b>1.</b>	Study of Mitotic Metaphase chromosome by aceto-orcein staining method and determination of chromosome number.	<b>08</b>
<b>2.</b>	Determination of Mitotic index in <i>Allium cepa</i> . OR Temporary preparation and study of different stages of meiosis from the flower buds	<b>06</b>
<b>3</b>	Demonstration of separation of Chlorophyll pigments by TLC. OR Determination of Molecular Weight of protein from Gel Electrophoresis data.	<b>06</b>
<b>4.</b>	Laboratory Note book	<b>02</b>
<b>5.</b>	<i>Viva voce</i>	<b>02</b>
<b>TOTAL</b>		<b>24</b>

**CONTENTS:**

1. Study of Mitotic Metaphase chromosome 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.* and determination of chromosome number (any three).
2. Determination of Mitotic index in *Allium cepa*.
3. Temporary preparation and study of different stages of meiosis from the flower buds of *Allium cepa*.
4. Demonstration of separation of Chlorophyll pigments by TLC. / Principle, requirements, procedure & precaution.
5. Determination of Molecular Weight of protein from Gel Electrophoresis data.
6. **Laboratory Records:** Student must get the laboratory note books duly signed by the respective teacher during practical classes.
7. Viva voce based on theory and practical syllabus of Paper 21 & 22A.

**Botany (Major)**  
**SEMESTER-VIII**  
**Ppaper-23 (Theory)**

**BT407C – Advanced Plant Physiology, Stress Physiology & Plant Developmental Biology**

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

**Credit = 04**

**Unit-I (Advanced Plant Physiology – I)**

1. Glyoxylate cycle and its significance.
2. Storage of carbohydrate in plants – Biochemistry of Starch biosynthesis and starch catabolism.
3. Fatty acid metabolism -  $\beta$ -oxidation of fatty acid.
4. Oxidative Phosphorylation and ATP synthesis (chemiosmotic mechanism).
5. Phloem transport - Pressure flow model, Phloem loading and unloading.
6. Signaling in plant - mechanism of auxin, cytokinin & gibberellin signalling.
7. Cryptochrome and Phototropin - Chemical nature and function.

**Unit-II (Advanced Plant Physiology – II)**

1. Flower development – Induction of floral meristem, Initiation of floral primordia, Specification of floral organs – ABC model.
2. Vernalization (role of low temperature in flowering).
3. Seed dormancy –Hormonal regulation of dormancy.
4. Seed germination– Mobilization of food reserves and role of growth regulators in seed germination.
5. Physiology of Senescence and Ageing – Changes during senescence, Hormonal regulation of senescence.
6. Abscission – Mechanism and hormonal regulation.

**Unit-III (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, hypotheses about mechanism of photoinhibition, and photoprotection (mechanical and biochemical protection, photochemical quenching & non-photochemical quenching).
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 (on growth, photosynthesis, reproduction, yield, production of reactive oxygen species) and Plant adaptation to heat stress - mechanism of avoidance & mechanism of tolerance, antioxidant defence & role of heat shock proteins (HSPs).
5. Salinity stress – effects of salinity on plants, salt tolerance and its mechanism (Osmotic tolerance,  $\text{Na}^+$  exclusion & Tissue tolerance)



#### **Unit-IV (Plant Developmental Biology)**

1. Initiation of leaf primordia and development of leaves.
2. Root development – Establishment of primary root meristem, Lateral root development.
3. Root nodule development in legumes – root nodule initiation and development.
4. Tuber development (in potato) – Changes during tuber development.
5. Embryo maturation and seed development – Changes during embryo maturation and seed development and their hormonal regulation.
6. Fruit ripening – climacteric and non-climacteric ripening, changes during ripening (including role of ethylene in ripening).

**Botany (Major)**  
**SEMESTER-VIII**  
**Paper-24A (Theory)**

**BT408C - Intellectual Property Rights and Computer Fundamentals & Bioinformatics)**

**Total Mark = 60 (IA = 16 + ESE = 36)**

**Credit = 02**

**Unit-I (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.

**Unit-II (Computer Fundamentals)**

1. **History of computers** – Characters of first, second, third, fourth & fifth generations of computers.
2. **Computer organization** – (i) CPU (Control unit, ALU & Memory unit), (ii) Computer memory - Cache Memory, Primary Memory/Main Memory (RAM, ROM – PROM, EPROM, EEPROM), Secondary Memory & Registers, (iii) Input devices (Keyboard, Mouse, Scanner, Touchpad, Barcode reader, OMR, Joystick), (iii) Output devices (Monitor, Printers, Plotters, Projector, Speaker, Head Phone).
3. **Computer Language** – Machine language, Assembly language, High level language.
4. **Computer softwares** – (i) System software (Operating system, Compiler, Assembler, & Interpreter) and (ii) Application softwares (Word processing software, Database software, Spreadsheet software, Presentation software, Multimedia software).
5. **Internet** – (i) Types of Networks – LAN, MAN, WAN, (ii) Hardware Requirements for the Internet – Modem, Hub, Bridge, Router, Gateway, (iii) Software Requirements for the Internet – Protocol, IP address, URLs, WEB browsers, Search engines.
6. **Definition and example of Computer virus and Antivirus.**
7. **Important Computer Security Threats** – Phishing, Spam, Malware, Adware, Spyware, Spoofing, Phraming & Keylogger.

### **Unit-III (Bioinformatics-I)**

1. Definition, Aims and Scope of Bioinformatics, Bioinformatics as interdisciplinary subject.
2. Concept of branches of Bioinformatics – Genomics, Proteomics, Transcriptomics, Systems Biology, Functional Genomics, Metaboliomics, 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.

### **Unit-IV (Bioinformatics-II)**

1. Concept of File format of biological database, File format types (definition and examples) - Sequence file formats and Molecular file formats.
2. Brief idea of BLAST – Standard BLAST and Mega BLAST, Application of BLAST tool in Biological Science.
3. NCBI and its role.
4. Basic concept of Protein Data Bank (PDB).
5. Role of Bioinformatics in industry – Food industry, Agricultural industry and Pharmaceutical industry.

**Botany (Major)**  
**SEMESTER-VIII**  
**Paper-24B (Practicals)**  
**BT408C**

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

**Credit = 02**

Sl. No.	Practical	Marks
1.	Plant Physiological Experiment	12
2.	Gram staining of <i>Rhizobia</i> from root nodules of leguminous plants.	06
3.	Laboratory Note book	03
4.	<i>Viva voce</i>	03
<b>TOTAL</b>		<b>24</b>

**CONTENTS:**

**1. Plant Physiological Experiment:**

- a) Determination of Osmotic Potential of *Rhoeo* leaf by plasmolytic method.
  - b) Study of effect of temperature on absorption of water by storage tissue and determination of Q10.
  - c) Determination of loss of water per stomata per hour.
  - d) Effect of CO<sub>2</sub> on the rate of Photosynthesis.
  - e) Measurement of oxygen uptake by respiring tissue (per g/hr).
  - f) Study of catalase activity.
  - g) Effect of salinity stress / heat stress on the rate of Photosynthesis.
2. Gram staining of *Rhizobia* from root nodules of leguminous plants.
  3. Submission of LNB.
  4. Viva voce based on theory and practical syllabus of Paper 23 & 24A.

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## **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, 2<sup>nd</sup> Edition, Wiley-Blackwell.
3. Pelczar, M.J. (2001), Microbiology, 5<sup>th</sup> edition, Tata McGraw-Hill Co, New Delhi.
4. Prescott, L.M., Harley J.P. and Klein D. A. (2005), Microbiology, 6<sup>th</sup> 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, 2<sup>nd</sup> edition, Affiliated East-West Press, Delhi.
2. Lee, R.E. (2008), Phycology, 4<sup>th</sup> 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, 4<sup>th</sup> edition, John Wiley & Sons (Asia), Singapore.
2. Deacon, J. W. (2006), Fungal Biology, 4<sup>th</sup> 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, 3<sup>rd</sup> 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 (1<sup>st</sup> Indian Ed), 2005, Oxford.

## **Evolution**

1. Futuyma, D. J. and Kirkpatrick, M. (2017), Evolution, 4<sup>th</sup> edition, Sinauer Associates, USA.
2. Rastogi, V. B. (2018), Organic Evolution, Pub: Medtech, New Delhi.
3. Ridley, M. (2004), Evolution, 3<sup>rd</sup> edition, Blackwell Publishing.
4. Strickberger, M. W. (2000), Evolution, 3<sup>rd</sup> 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, 3<sup>rd</sup> 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, 2<sup>nd</sup> 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, 3<sup>rd</sup> edition, John Willey & 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 (2<sup>nd</sup> 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 (6<sup>th</sup> 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.), 1992, Wadsworth 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 (6<sup>th</sup> Ed), 2015, Garland Science.
2. Cooper, G.M. The Cell, A Molecular Approach (4<sup>th</sup> 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 (11<sup>th</sup> Ed), 2016, Pearson Education.
6. Marshall, W. and Iwasa, J. Karp's Cell and Molecular Biology (8<sup>th</sup> Ed), 2016, Wiley.
7. Pierce, Benjamin A. Genetics A Conceptual Approach (5<sup>th</sup> 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 (6<sup>th</sup> 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 (7<sup>th</sup> Ed), 2014, Pearson Education Inc.
12. Weaver, R.F. Molecular Biology (5<sup>th</sup> 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 (8<sup>th</sup> Ed), Cambridge.

## **Economic Botany**

1. Pandey, B. P. Economic Botany (6<sup>th</sup> 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 (7<sup>th</sup> ed.), 2005, Kalyani Publishers.
9. Spiegel, M. R. And Stephens, L. J. Schaum's Outlines Statistics, (4<sup>th</sup> Ed), McGraw-Hill.

## **Horticulture & Floriculture**

1. Acquaah, G. Horticulture – Principles and Practices (4<sup>th</sup> Ed), 2009, Pearson.
2. Adams, C. R., Bamford, K. M. and Early, M. P. Principles of Horticulture, (5<sup>th</sup> 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 (48<sup>th</sup> Ed), 2013, Nirali Prakashan.
2. Shah, B. and Seth, A. K. Text Book of Pharmacognosy & Phytochemistry (1<sup>st</sup> Ed), 2010, Elsevier.
3. Trease & Evans, Pharmacognosy (16<sup>th</sup> 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 (2<sup>nd</sup> 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 (4<sup>th</sup> 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 (2<sup>nd</sup> 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, 3<sup>rd</sup> 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, 3<sup>rd</sup> edition, New Central Book Agency (P) Ltd., Kolkata.
5. Sharma, P.D. (2004), Ecology and Environment, 7<sup>th</sup> 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, 1<sup>st</sup> 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, 2<sup>nd</sup> Revised Edition, New Age Intl.

### **Intellectual Property Rights (IPR)**

1. Ahuja, V. K. 2017, Law Relating to Intellectual Property Rights, 3<sup>rd</sup> 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, 5<sup>th</sup> edition, Universal law Publishing Co.

### **Computer Fundamentals**

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

3. Thareja, R. 2019, Fundamentals of Computer, 2<sup>nd</sup> 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.

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