



UNIVERSITY OF CALCUTTA

Dr. MILAN KUMAR PAL, M.Sc., Ph.D.
O.S.D.
UNIVERSITY OF CALCUTTA.

Ref No. CUS/ 189 (cir.)/16
Dated the 15th December, 2016

SENATE HOUSE
87/1, College Street, Kolkata-700073
Phone : 2257-3376, 2241-0071-74,
2241-4984-86, 2241-4989-90,
2241-2850-51, 2241-2859
Fax : 91-033-2241-3222
E-mail : u.g.councilsc.u@gmail.com
Website : www.caluniv.ac.in

To
The Principals /T.I.C.
of all the Undergraduate Colleges
offering B.Sc. (Honours) in Botany
affiliated to the University of Calcutta

Sir/Madam,

The undersigned would like to forward you the **Draft Syllabus for Botany (Honours)**, to be implemented from the academic session 2017-2018 to get feedback from the Department of Botany in your college.

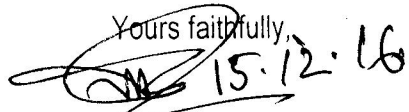
You are requested to send your feedback within 30th December, 2016.

In this regard you may send your observation/ suggestion to the **Department of U.G. Councils, C.U.** or through **email (u.g.councilsc.u@gmail.com)** or you may contact **Prof. Subir Bera (Mob: 9831750553; e-mail: berasubir@yahoo.co.in)** / **Dr. Binod Kumar Pathak (Mob:9477233704; e-mail: pathakbk112@gmail.com)**.

Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Encl: Copy of the Draft Syllabus.

Yours faithfully,

(Milan Kr. Pal)
O.S.D., C.U.

UNIVERSITY OF CALCUTTA
DRAFT SYLLABUS
FOR
THREE-YEAR B.Sc. HONOURS COURSE
UNDER 1+1+1 SYSTEM
OF EXAMINATION



BOTANY 2017

**Syllabus for three-year B.Sc. Botany Honours Course (With
effect from 2017-2018)**

C.U. B.Sc. BOTANY (HONOURS), 2017

PART I: 225 MARKS

(THEORETICAL -150 and PRACTICAL – 75)

PAPER I (THEORETICAL) 100 MARKS 4 Hours

Algae	25 Marks (20 Periods)
Microbiology	25 Marks (20 Periods)
Fungi & Lichen	25 Marks (20 Periods)
Plant Pathology	25 Marks (20 Periods)

PAPER IIA (THEORETICAL) 50 MARKS 2 HOURS

Bryophytes	20 Marks (16 Periods)
Palaeobotany & Palynology	20 Marks (16 Periods)
Embryology	10 Marks (8 Periods)

PAPER IIB (PRACTICAL) 75 MARKS 6 HOURS

1. Work out: Algae, Fungi, Bacterial staining, Inoculation (Plant Pathology-Demonstration)
(12+12+10+5)= 39 Marks
2. Identification with reasons: (Algae-1, Fungi-1, Lichen-1, Bryophytes-2, Pathology-1, & Palaeobotany- 1)
3x7 = 21 Marks
3. Classroom performance
(Attendance, Lab notebook, submission and permanent slides) (3+4+3)= 10 Marks
4. Viva 5 Marks

Module I: Algae + Microbiology

Module II: Fungi & Lichen + Plant Pathology

Module III: Bryophyte+ Palaeobotany & Palynology+ Embryology

Module IV: Work out on Algae, Fungi, Microbiology and Pathology + Identification + Classroom performance + Viva-voce

PART II: 225 MARKS
(THEORETICAL -150 and PRACTICAL – 75)

PAPER III (THEORETICAL): 100 MARKS 4 HOURS

Anatomy	25 Marks (20 Periods)
Pteridophytes	25 Marks (20 Periods)
Gymnosperms	20 Marks (20 Periods)
Ecology and Plant Geography	20 Marks (20 Periods)
Evolution	10 Marks (10 Periods)

PAPER IVA (THEORETICAL): 50 MARKS 2 HOURS

Morphology of Angiosperms	10 Marks (8 Periods)
Taxonomy of Angiosperms	40 Marks (32 Periods)

PAPER IVB (PRACTICAL): 75 MARKS 6 HOURS

1. Workout on Pteridophytes, Angiosperms and Anatomy
(9+12+10) = 31 Marks
2. Spot Identification (1.5 x4) = 6 Marks
3. Identification with reasons
(Pteridophyte – 1, Gymnosperms – 2, Anatomy-2) (3 x 5) = 15 Marks
4. Classroom performance: (Attendance, lab records, slides)
(3+5+2) = 10 Marks
5. Field Records (Field note book–2, Ecological notebook-2, Herbarium specimens–4)
8 Marks
6. Viva-voce 5 Marks

Module V: Anatomy + Pteridophytes

Module VI: Gymnosperm + Ecology & Plant Geography + Evolution

Module VII: Morphology of Angiosperms + Taxonomy of Angiosperms

Module VIII: Work out on Pteridophytes, Angiosperms & Anatomy+ Spot Identification of Angiosperms + Identification + Classroom performance + Field Records (Field records) + Viva-voce.

PART III: 350 MARKS

(THEORETICAL -200 and PRACTICAL – 150)

PAPER V (THEORETICAL): 100 MARKS 4 HOURS

Plant Physiology	50 Marks (40 Periods)
Biochemistry	35 Marks (28 Periods)
Pharmacognosy	15 Marks (12 Periods)

PAPER VI (THEORETICAL): 100 MARKS 4 HOURS

Cell Biology	20 Marks (16 Periods)
Plant Breeding & Biometry	15 Marks (12 Periods)
Plant Biotechnology	15 Marks (12 Periods)
Genetics & Molecular Biology	50 Marks (40 Periods)

Module IX: Plant Physiology

Module X: Biochemistry + Pharmacognosy

Module XI: Cell Biology + Plant Breeding & Biometry + Plant Biotechnology

Module XII: Genetics & Molecular Biology

PAPER VII (PRACTICAL):75 MARKS 6 HOURS

1. Plant Physiology		20 Marks
2. Plant Biochemistry (Quantitative & Qualitative)	(20+10) =	30 Marks
3. Pharmacognosy		10 Marks
4. Classroom performance: (Attendance and Laboratory records)	(3+7) =	10 Marks
5. Viva-voce		5 Marks

PAPER VIII (PRACTICAL)

1. Cell Biology and Genetics	(20+10) =	30 Marks
2. Biometry		15 Marks
3. Identification (Cell Biology 4)	(3X4)=	12 Marks
4. Classroom performance (Attendance, Laboratory Records and slides)	3+3+2=	8 Marks
5. Review of/ Project on any topic of interest to the student from any field of botany		5 Marks
6. Viva-voce		5 Marks

Module XIII: Plant physiology + Biochemistry + Pharmacognosy + Classroom performance + Viva

Module XIV: Cell Biology & Genetics + Biometry+ Identification + Classroom performance + Viva-voce

PAPER I (THEORETICAL): 100 MARKS: 4 HOURS

Algae	25 Marks (20 Periods)
Microbiology	25 Marks (20 Periods)
Fungi & Lichen	25 Marks (20 Periods)
Plant Pathology	25 Marks (20 Periods)

PAPER I (THEORETICAL)

ALGAE

25 Marks (20 Periods)

1. *General account* :

1.1. Thallus organization, Structure of algal cell, 1.2. Ultrastructure of Plastids and Flagella, 1.3. Origin and evolution of sex, 1.4. Life cycle patterns.

2. *Classification* :

2.1. Criteria and basis of Fritsch's classification

2.2. Classification by Lee (2008) upto phylum with examples

2.3. Salient features of Cyanobacteria, Rhodophyta, Chlorophyta, Charophyta, Bacillariophyta, Xanthophyta, Phaeophyta, Heterokantophyta.

3. *Cyanobacteria* :

3.1. Ultrastructure of cell, 3.2. Heterocyst - structure and function.

4. *Bacillariophyta* :

4.1. Cell structure, 4.2. Cell division, 4.3. Auxospore formation in Centrales and Pennales.

5. *Life History* :

5.1. *Chlamydomonas*, 5.2. *Oedogonium*, 5.3. *Chara*, 5.4. *Ectocarpus*, 5.5. *Polysiphonia*.

6. *Applied phycology* :

6.1. Algae as food and source of phycocolloid (Agar-agar, Algin, Carrageenan), 6.2. Diatomite, 6.3. Algal toxin, 6.4. Algal Biotechnology – potential of microalgae for SCP, β -carotene, Biodiesel.

MICROBIOLOGY

25 Marks (20 Periods)

1. *Virus* :

1.1. Plant virus- types, 1.2. Transmission and translocation of Plant virus, 1.3. TMV- Physicochemical characteristics and Multiplication, 1.4. One step growth curve, 1.5. Lytic cycle (T4 phage) and Lysogenic cycle (Lambda phage), Significance of lysogeny, 1.6. Viroids and Prions.

2. *Bacteria* :

2.1. Distinguishing features of Archaea and Bacteria, 2.2. Characteristics of some major groups: Proteobacteria (Enterobacteria), Firmicutes, Mollicutes, Actinobacteria, Spirochaetes, Chlamydiae, 2.3. Bacterial growth curve and generation time, 2.4. Flagella (ultrastructure) & Pili, 2.5. Cell wall – chemical structure and differences between Gram +ve & Gram – ve bacteria, 2.6. Bacterial genome and plasmid, 2.7. Endospore - formation, structure and function, 2.8. Genetic Recombination (a) Transformation – with special emphasis on Natural and Induced competence and DNA uptake, (b) Conjugation— F- factor, F^+ X F^- , Hfr X F^- , concept of F' , chromosome mobilization, (c) Transduction— Generalised and specialised.

3. *Applied Microbiology* :

3.1. Industrial Production of Vinegar and Streptomycin (brief outline), 3.2. Microbial sources and uses of Enzyme (Amylase, Protease), Amino acid (Glutamic acid, Lysine), Polysaccharides (Dextran), 3.3. Use of microbes as Biofertilizer and Biopesticides, 3.4. Use of microbes in mineral processing.

FUNGI & LICHEN

25 Marks (20 Periods)

1. *General Account* :

1.1. Hyphal forms, 1.2. Fungal spore forms and mode of liberation, 1.3. Sexual reproduction and degeneration of sex, 1.4. Parasexuality and sexual compatibility, 1.5. Life cycle patterns.

2. *Classification* :

2.1. Classification of Fungi (Ainsworth, 1973) upto sub-division with diagnostic characters and examples. 2.2. General characteristics of Myxomycota, Oomycota, Zygomycota, Ascomycota, Basidiomycota, Deuteromycota.

3. *Life history* :

3.1. *Synchytrium*, 3.2. *Rhizopus*, 3.3. *Ascobolus*, 3.4. *Agaricus*.

4. *Mycorrhiza* :
 - 4.1. Types with salient features, 4.2. Role in Agriculture & Forestry.
5. *Applied mycology* :
 - 5.1. Fungi as food, 5.2. Cheese and Ethanol- Industrial production (brief outline), 5.3. Fungal sources and uses of Enzyme (Cellulase), Amino acid (Tryptophan), Vitamin (Riboflavin), Antibiotic (Griseofulvin), Pharmaceuticals (Cyclosporin-A). 5.4. Aflatoxin
6. *Lichen* :
 - 6.1. Types, 6.2. Reproduction, 6.3. Economic and ecological importance

PLANT PATHOLOGY

25 Marks (20 Periods)

1. *Terms and Definitions* :
 - 1.1. Disease concept, 1.2. Symptoms, 1.3. Etiology & causal complex, 1.4. Primary and secondary inocula, 1.5. Infection, 1.6. Pathogenecity and pathogenesis, 1.7. Necrotroph and Biotroph, 1.8. Koch's Postulates, 1.9. Endemic, Epidemic, Pandemic and Sporadic disease, 1.10. Disease triangle, 1.11. Disease cycle (monocyclic, polycyclic and polyetic).
2. *Host – Parasite Interaction* :
 - 2.1. Mechanism of infection (Brief idea about Pre-penetration, Penetration and Post-penetration), 2.2. Pathotoxin (Definition,criteria and example), 2.3. Defense mechanism with special reference to Phytoalexin, 2.4. Resistance- Systemic acquired and Induced systemic.
3. *Plant Disease Management* :
 - 3.1. Quarantine, 3.2. Chemical, 3.3. Biological, 3.4. Integrated.
4. *Symptoms , Causal organism ,, Disease cycle and Control measures of* :
 - 4.1. Late blight of Potato, 4.2. Brown spot of rice, 4.3. Black stem rust of wheat, 4.4. Stem rot of jute.

PAPER IIA (THEORETICAL): 50 MARKS: 2 HOURS

Bryophytes	20 Marks (16 Periods)
Palaeobotany & Palynology	20 Marks (16 Periods)
Embryology	10 Marks (8 Periods)

PAPER IIA (THEORETICAL)

BRYOPHYTES

20 Marks (16 Periods)

1. *General Account* :
 - 1.1. General characteristics and adaptations to land habit, 1.2. Classification (Strotler and Crandle Strotler, 2009) upto class with diagnostic characters and examples.
2. *Life History*: Gametophyte structure and Reproduction, Development and Structure of sporophyte, Spore dispersal in:
 - 2.1. *Marchantia*, 2.2. *Anthoceros*, 2.3. *Funaria*.
3. *Phylogeny* :
 - 3.1. Origin of Alternation of Generations (Homologous and Antithetic theory), 3.2. Evolution of Sporophytes (Progressive and Regressive concept), 3.3. Origin of Bryophytes.
4. *Importance* :

Role of bryophytes in: 4.1. Plant succession, 4.2. Pollution Monitoring, 4.3. Economic importance of bryophytes with special reference to *Sphagnum*.

PALAEOBOTANY & PALYNOLOGY

20 Marks (16 Periods)

1. *Plant Fossil* :
 - 1.1. Types: Body fossil (Micro- and Megafossils), Trace fossil, Chemical fossil, Index fossil, 1.2. Different modes of preservation (Schopf, 1975), 1.3. Conditions favouring fossilization, 1.4. Nomenclature and Reconstruction, 1.5. Principle of fossil dating (a brief idea), 1.6. Importance of fossil study.
2. *Geological time scale* with dominant plant groups through ages.

3. *Indian Gondwana System* - Three fold division with major megafossil assemblages.

4. *Palynology* :

4.1. Spore and Pollen, 4.2. Pollen aperture types, 4.3. NPC classification (Erdtman). 4.4. Pollen wall- Sporopollenin, Stratification and Ornamentation (sculpturing).

5. *Applied Palynology*:-

Basic concepts of: 5.1.Palaeopalynology, 5.2.Aeropalynology, 5.3.Forensic palynology, 5.4.Melissopalynology.

EMBRYOLOGY

10 Marks (8 Periods)

1. *Pre-fertilisation changes* :

1.1. Microsporogenesis and Microgametogenesis, 1.2. Megasporogenesis and Megagametogenesis (monosporic, bisporic and tetrasporic).

2. *Fertilisation*:

2.1. Pollen germination, 2.2. Pollen tube— growth, entry into ovule and discharge, 2.3. Double fertilization.

3. *Post-fertilization changes* :

3.1. Embryogenesis in *Capsella*, 3.2. Development of Endosperm (3 types).

4. *Apomixis & Polyembryony*:

4.1. Apomixis- Apospory and Apogamy, 4.2.Polyembryony- different types.

PAPER IIB (PRACTICAL): 75 MARKS: 6 HOURS

1. Work out: Algae, Fungi, Bacterial staining, Inoculation (Plant Pathology-Demonstration)	(12+12+10+5)=	39 Marks
2. Identification with reasons: (Algae-1, Fungi-1, Lichen-1, Bryophytes-2, Pathology & Palaeobotany-1)	(3x7) =	21 Marks
3. Classroom performance (Attendance, Lab notebook, submission and permanent slides)	(3+4+3)=	10 Marks
4. Viva- voce		5 Marks

PAPER IIB (PRACTICAL)

ALGAE

1. Work out of the following algae with reproductive structure (Free hand drawing and drawing under drawing prism with magnification): *Oedogonium*, *Chara*, *Ectocarpus*.
2. Study of (a) Permanent slides : *Gloeoitrichia*, *Volvox*, *Vaucheria*, *Coleochaete*, *Polysiphonia*, Centric and Pennate diatom; (b) Macroscopic specimens : *Laminaria*, *Sargassum*.

FUNGI AND LICHEN

1. Work out of the following fungi with reproductive structures (including microscopic measurement of Reproductive structures): *Rhizopus* (asexual), *Ascobolus*, *Agaricus*.
2. Study from permanent slides: Zygosporangium of *Rhizopus*, Conidia of *Fusarium*, Conidiophore of *Penicillium*.
3. Morphological study of Fungi (fruit body of *Polyporus*, *Cyathus*), Lichens (fruticose and foliose).

BRYOPHYTES

1. Morphological study of the plant body: Genera as mentioned in theoretical syllabus and *Riccia*, *Porella*.
2. Study from permanent slides : *Riccia* (V.S. of thallus with sporophyte), *Marchantia* (L.S.through gemma cup, antheridiophore , archegoniophore), *Anthoceros* (L.S. of sporophyte) , *Funaria* (L.S. of capsule) .

MICROBIOLOGY

1. Preparation of bacterial media – (a) Nutrient agar and nutrient broth, (b) Preparation of slants and pouring Petri-plates.
2. Sub-culturing of bacterial culture.
3. Gram staining from bacterial culture.
4. Microscopic examination of bacteria from natural habitat (curd) by simple staining.

PLANT PATHOLOGY

1. Preparation of fungal media (PDA).
2. Sterilization process.
3. Isolation of pathogen from diseased leaf.
4. Inoculation of fruit and subculturing.
5. Identification : Pathological specimens of Brown spot of rice, Bacterial blight of rice ,Loose smut of wheat, Stem rot of jute, Late blight of potato; Slides of uredial, telial, pycnial & aecial stages of *Puccinia graminis*.

FIELD WORK

At least one local excursion to be conducted for study and collection of algae and macrofungi (at least 10 each) and another local excursion should be conducted to give idea about plant diversity (Collection not required).

CLASSROOM PERFORMANCE

1. Attendance: A certificate of percentage of attendance in practical classes from the concerned teacher should be attached with lab note books.
2. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes
3. Slides (permanent) prepared during practical classes.
4. Submission (Algae and Macro fungi)

PART II: 225 MARKS

(THEORETICAL -150 and PRACTICAL – 75)

PAPER III (THEORETICAL) 150 MARKS: 4 HOURS

Anatomy	25 Marks (20 Periods)
Pteridophytes	25 Marks (20 Periods)
Gymnosperms	20 Marks (20 Periods)
Ecology and Plant Geography	20 Marks (20 Periods)
Evolution	10 Marks (10 Periods)

PAPER III (THEORETICAL)

ANATOMY

25 Marks (20 Periods)

1. *Cell wall*:
 - 1.1. Ultrastructure & Chemical constituents, 1.2. Plasmodesmata- ultrastructure, 1.3. Concept of Apoplast and Symplast, 1.4. Growth and Thickening of cell wall.
2. *Stomata* :
 - 2.1. Types (Metcalf and Chalk, Stebbins and Khush), 2.2. Ontogeny.
3. *Ontogeny of* 3.1. Trachea and 3.2. Sieve-tube.
4. *Stele* :
 - 4.1 Leaf-trace and leaf-gap, 4.2. Stellar types & evolution
5. *Primary structure of stem and root*- Monocot and Dicot

6. *Secondary growth*:
 - 6.1. Normal (intra- & extra-stelar), 6.2. Anomalous (stem of *Bignonia*, *Boerhavia*, *Tecoma*, *Dracaena* and root of *Tinospora*).
7. Mechanical tissues and the Principles governing their distribution in plants.
8. Developmental Anatomy :
 - Organisation of shoot apex (Tunica–Corpus) and Root apex (Korper-Kappe), 7.2. Plastochrone.
9. *Ecological Anatomy*:
 - Adaptive anatomical features of 9.1. Hydrophytes, 9.2. Xerophytes.

PTERIDOPHYTES

25 Marks (20 Periods)

1. *General Account* :
 - 1.1. Colonisation and rise of early land plants, 1.2. Classification of vascular plants by Gifford & Foster (1989) upto division (Rhyniophyta to Filicophyta) with diagnostic characters and examples.
2. *Life History* :
 - Sporophyte structure, Reproduction and Structure of gametophyte in 2.1. *Psilotum*, 2.2. *Selaginella*, 2.3. *Equisetum*, 2.4. *Pteris*.
3. *Fossil Pteridophytes* :
 - Structural features, Geological distribution and Evolutionary significance of 3.1. Rhynia, 3.2. *Lepidodendron* (Reconstructed) 3.3. *Calamites* (Reconstructed).
4. *Telome concept* and its significance in the origin of different groups of Pteridophytes.
5. *Heterospory and Origin of Seed habit*.
6. *Economic importance* as food, medicine and Agriculture.

GYMNOSPERMS

25 Marks (20 Periods)

1. *Classification* of vascular plants by Gifford & Foster (1989) upto division (Progymnospermophyta to Gnetophyta) with diagnostic characters and examples.
2. *Progymnosperms* :
 - 2.1. Diagnostic characters of the group, 2.2. Vegetative and reproductive features of *Archeopteris*, 2.3. Phylogenetic importance.
3. *Life History* :
 - Distribution in India; Vegetative and Reproductive structure of sporophyte, Development of gametophyte and Embryogeny in : 3.1. *Cycas*, 3.2. *Pinus* and 3.3. *Gnetum*.
4. *Fossil gymnosperms* :
 - Structural features and Geological distribution of reconstructed genera: 4.1. *Lyginopteris*, 4.2. *Williamsonia*, 4.3. *Cordaites*.
5. *Economic Importance* with reference to Wood, Resins, Essential oils, and Drugs.

ECOLOGY

1. *Preliminary idea on* :
 - 1.1. Habitat and Niche, 1.2. Ecotone and edge–effect, 1.3. Microclimate, 1.4. Ecads, ecotype and ecoclines, 1.5. Carrying capacity.
2. *Community ecology* :
 - 2.1. Community- Characteristics and diversity, 2.2. Ecological succession –Primary and secondary, Seral stages (with reference to Hydrosere), autogenic and allogenic succession.
 3. 3.1. Plant indicators (metallophytes); 3.2. Phytoremediation.
4. *Conservation of Biodiversity*: 4.1. Level of Biodiversity: genetic, species & ecosystem diversity, 4.2. Biodiversity hot spots- criteria, Indian hotspots, 4.3. *In-situ and ex-situ* conservation, 4.4. Seed-banks, 4.5. Cryopreservation, 4.6. Geographic Information System and Remote Sensing (brief idea).

PLANT GEOGRAPHY

1. *Phytogeographical regions* :
 - 1.1. Phytogeographical regions of India (Chatterjee 1960); 5.2. Dominant flora of Eastern Himalaya, Western Himalaya and Sunderban.
2. *Endemism* :
 - 1.2. Endemic types and Factors; 6.2. Age & Area hypothesis and Epibiotic theory; 6.3. Endemism in Indian flora.

EVOLUTION

1. 1.1 Introduction, 1.2. Theories of evolution: Natural selection, Group selection, Neutral theory of molecular evolution, 1.3. Phyletic gradualism, Punctuated equilibrium and Stasis
2. Brief idea on: Stabilizing, directional, disruptive and sexual selection; Speciation: Sympatric and allopatric speciation; Coevolution, Adaptive radiation, Reproductive isolation
3. 3.1. Simplified phylogeny of bacteria, algae, fungi, bryophyte, pteridophyte and gymnosperm, 3.2. Phylogenetic tree

PAPER IVA (THEORETICAL): 50 MARKS: 2 HOURS

Morphology of Angiosperms
Taxonomy of Angiosperms

10 Marks (8 Periods)
40 Marks (32 Periods)

PAPER IVA (THEORETICAL)

MORPHOLOGY OF ANGIOSPERMS

10 Marks (8 Periods)

1. *Inflorescence* types with examples.
2. *Flower*
3. *Fruits and seeds* - types with examples.

TAXONOMY OF ANGIOSPERMS

40 Marks (32 Periods)

1. *Introduction* :
 - 1.1. Components of Systematic: Nomenclature, Identification, Classification; 1.2. Taxonomy and its phases - Pioneer, Consolidation, Biosystematic and Encyclopaedic; alpha- and omega- taxonomy.
2. *Nomenclature* :

Type method, Publication, Rank of taxa, Rules of priority, Retention and rejection of names, Author Citation, Effective and valid publication, Elementary knowledge of ICN- Principles.
3. *Systems of classification* :

Broad outline of Bentham & Hooker (1862-1883), Cronquist (1988), Takhtajan (1991) - system of classification with merits and demerits

 - 3.1. *Systematics in Practice*: Herbaria and Botanical Gardens – their role in teaching and research; important Herbaria and Botanical Gardens of India and world (3 each); 4.2. Dichotomous keys – indented and bracketed.
4. *Phenetics and Cladistics* :

Brief idea on Phenetics, Numerical taxonomy- methods and significance; Cladistics- construction of dendrogram and primary analysis; Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy.
5. *Data sources in Taxonomy*:

Supportive evidences from: 5.1. Phytochemistry, 5.2. Cytology, 5.3. Palynology and 5.4. Molecular biology data (Protein and Nucleic acid homology).
7. *Diagnostic features, Systematic position (Bentham & Hooker and Cronquist), Economically important plants (parts used and uses) of the following families*:
 - 7.1. Monocotyledons: Alismataceae, Gramineae (Poaceae), Cyperaceae, Palmae (Arecaceae), Liliaceae, Musaceae, Zingiberaceae, Cannaceae, Orchidaceae.
 - 7.2. Dicotyledons : Nymphaeaceae, Magnoliaceae, Leguminosae (subfamilies), Polygonaceae, Euphorbiaceae, Malvaceae, Umbelliferae (Apiaceae), Labiatae (Lamiaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Compositae (Asteraceae)

PAPER IVB (PRACTICAL): 75 MARKS: 6 HOURS

1. Workout on Pteridophytes, Angiosperms and Anatomy (9+12+10) = 31 Marks
2. Spot Identification (1.5 x4) = 6 Marks
3. Identification with reasons (Pteridophyte – 1, Gymnosperms – 2, Anatomy-2)
(3 x 5) = 15 Marks
4. Classroom performance: (Attendance, lab records, slides) (3+5+2)= 10 Marks
5. Field Records (Field note book–2, Ecological notebook-2, Herbarium specimens–4)
8 Marks
6. Viva-voce 5 Marks

PAPER IVB (PRACTICAL)

PTERIDOPHYTES

1. Morphological study of the sporophytic plant body: Genera as mentioned in the theoretical syllabus and *Lycopodium*, *Ophioglossum*, *Marsilea* and *Pteris*.
2. Workout of the reproductive structures: *Selaginella*, *Equisetum*, *Pteris*.
3. Study from permanent slides : *Psilotum* (T.S. of synangium), *Lycopodium* (L.S. of strobilus), *Ophioglossum* (L.S. of spike), *Dryopteris* (gametophyte), *Marsilea* (L.S. of sporocarp)

ANGIOSPERMS

1. Study of types of inflorescence, flower and fruit (from specimens).
2. Work out, description, preparation of floral formula and floral diagram, identification up to genus with the help of suitable literature of wild plants from the following families: Malvaceae, Fabaceae (Papilionaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.
3. Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus (list to be provided).

ANATOMY

1. Microscopic studies on: Types of stomata, sclereids, raphides (*Colocasia*), cystolith (*Ficus* leaf) starch grains, aleurone grains, laticiferous ducts, oil glands.
2. Study of anomalous secondary structure in stem of *Bignonia*, *Boerhaavia*, *Tecoma*, *Dracaena* and root of *Tinospora*
3. Study of adaptive anatomical features: Hydrophytes (*Nymphaea* – petiole) and Xerophytes (*Nerium* – leaf).

FIELD WORK

1. At least four excursions including one long excursion to a specialized phytogeographical zone of India and one to Acharya Jagadish Chandra Bose Indian Botanic Garden (Shibpur, Howrah) and Central National Herbarium (CNH).
2. Study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Frequency, density and abundance of components (to be done during excursion).

FIELD RECORDS

1. Field Note Book (authenticated) with field notes on the plants of the area of excursion and voucher specimen book.
2. Herbarium specimen: Preparation of 25 angiospermic specimens (identified with author citation, voucher number and arranged following Bentham & Hooker's system of classification) to be submitted in the University Examination.

GYMNOSPERMS

1. Morphological study: *Cycas* (microsporophyll and megasporophyll), *Pinus* (female and male cone), *Gnetum* (female and male cone).
2. Study from permanent slides: *Cycas* (L.S. of ovule), *Pinus* (L.S. of male and female cone), *Ginkgo* (L.S. of female strobilus), *Gnetum* (L.S. of male cone and ovule).

PALAEOBOTANY AND PALYNOLOGY

1. Morphological study: *Ptilophyllum* and *Glossopteris* leaf fossils.
2. Study from permanent slides: T.S. of stem of *Rhynia*, *Lepidodendron*, *Calamites*, *Lyginopteris*, *Cordaites*.
3. Study of Pollen types (colpate, porate and colporate) from permanent slides. Slides may be prepared from specimens: Colpate (*Leonurus sibiricus*/ *Brassica* sp.), Porate (*Hibiscus rosa-sinensis*), Colporate (*Cassia sophera*/ *C. tora*).

CLASSROOM PERFORMANCE

1. Attendance: A certificate of percentage of attendance in practical classes from the concerned teacher should be attached with lab note books.
2. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes
3. Slides (permanent) prepared during practical classes.

PART III: 350 MARKS (THEORETICAL -200 AND PRACTICAL – 150)

PAPER V (THEORETICAL): 100 MARKS: 4 HOURS

Plant Physiology	50 Marks (40 Periods)
Biochemistry	35 Marks (28 Periods)
Pharmacognosy	15 Marks (12 Periods)

PAPER V (THEORETICAL)

PLANT PHYSIOLOGY

50 Marks (40 Periods)

1. *Plant-water relations*:
 - 1.1 Concept of water potential, components of water potential in plant system, 1.2. Soil-plant-Atmosphere continuum concept, Cavitation in xylem and embolism, 1.3. Stomatal physiology-mechanism of opening and closing, Role of carbon di-oxide, potassium ion, abscisic acid and blue light in stomatal movement, Antitranspirants.
2. *Organic Translocation* :
 - 2.1 Phloem sap, P-protein, 2.2. Phloem loading and unloading, 2.3. Mass-flow (pressure flow) hypothesis and its critical evaluation.
3. *Photosynthesis* :
 - 3.1 Chemical structure of chlorophyll a and b, absorption and action spectra, biological significance of carotenoid pigments, 3.2. Red drop and Emerson effect, Components of photosystems (light harvesting complex), Photochemical reaction centres, Cyclic and noncyclic electron transport, Water splitting mechanism, 3.3. Calvin cycle – Biochemical reactions & stoichiometry, 3.4. HSK Pathway– three variants of the pathway, 3.5. Photosynthetic efficiency of C₃ and C₄ plants and crop productivity, 3.6. Photorespiration – mechanism and significance, 3.7. Crassulacean Acid metabolism– mechanism and ecological significance.
4. *Respiration* :
 - 4.1 EMP pathway, regulation and its anabolic role, 4.2. Conversion of Pyruvic acid to Acetyl CoA, 4.3. TCA-cycle and its amphibolic role, 4.4. Oxidative pentose phosphate pathway and its significance, 4.5. β-oxidation of fatty acids and significance, 4.6. Mitochondrial electron transport system, uncouplers, 4.7. Oxidation of cytosolic NADH+H⁺ 4.8. Stoichiometry of glucose oxidation (aerobic).
5. *Nitrogen Metabolism* :
 - 5.1 Assimilation of nitrate by plants, 5.2. Biochemistry of dinitrogen fixation in *Rhizobium*, 5.3. General principle of amino acid biosynthesis (including GS and GOGAT enzyme system).
6. *Plant Growth Regulators* :
 - 6.1. Physiological roles of Auxin, Gibberellin, Cytokinin, Abscisic acid, Ethylene, 6.2. Chemical nature –IAA, GA₃, Kinetin, 6.3. Biosynthesis and bioassay of IAA, 6.4. Mode of action of IAA, 6.5. Brassinosteroids and Polyamines as

PGRs (brief idea).

7. *Photomorphogenesis* :

7.1 Concept of photomorphogenesis, 7.2. Photoperiodism and plant types, 7.3. Perception of photoperiodic stimulus, 7.4. Critical day length, concept of light monitoring, 7.5. Phytochrome – chemical nature, interconversion, function in flowering, 7.6. Role of GA in flowering, 7.7. Vernalisation – role of low temperature in flowering, 7.8. Concept of biological clock and biorhythm .

8. *Seed dormancy*: 8.1. Types, Causes and Methods of breaking seed dormancy, 8.2. Biochemistry of seed germination.

9. Physiology of Senescence and Ageing.

10. *Physiology and molecular biology of stress*: Plant responses to: 10.1. Water stress, 10.2. Temperature stress, 10.3. Salt stress.

BIOCHEMISTRY

35 Marks (28 Periods)

1. *Biochemical Foundations* :

1.1. Covalent and non-covalent bonds; hydrogen bond; Van der Waal's forces; 1.2. Structure and properties of water; 1.3. pH and buffer (inorganic and organic); 1.4. Handerson-Hasselbalch equation; 1.5. Isoelectric point.

2. *Molecules of life* :

2.1. Nucleic Acids – structure of nucleosides and nucleotides ; oligo- and poly nucleotides , B & Z form of DNA, RNA- different forms; nucleotide derivatives (ATP, NADP), 2.2. Proteins – structure and classification of amino acids; primary, secondary, tertiary and quaternary structure of proteins; 2.3. Carbohydrates - structure of mono-, di- and polysaccharide; stereoisomers, enantiomers and epimers; 2.4. Lipids - structure of simple lipid and compound lipid (phospholipids and glycolipids), fatty acids- saturated and unsaturated.

3. *Energy flow and enzymology* :

3.1. Bioenergetics-Thermodynamic principles; free energy; energy rich bonds- phosphoryl group transfer and ATP; redox potentials and Biological redox reactions, 3.2. Enzymes – classification and nomenclature (IUBMB); Co-factors and co-enzymes; isozymes, 3.3. Mechanism of enzyme action; enzyme inhibition; 3.4. Enzyme kinetics (Michaelis-Menten equation) and simple problems.

4. *Cell membrane and Biosignalling* :

4.1. Membrane chemistry, 4.2. Membrane transport (uniport, symport, antiport), mechanism of ion uptake 4.3. Signal Transduction pathway and second messenger concept - G-protein and Ca

5. *Phosphorylation*: ATP Synthesis- Chemiosmotic model, Oxidative and Photophosphorylation- Mechanism and differences.

PHYTOCHEMISTRY AND PHARMACOGNOSY

15 Marks (12 Periods)

1. *General account* :

1.1 Pharmacognosy and its importance in modern medicine, 1.2 Crude drugs, 1.3 Classification of drugs- chemical and pharmacological, 1.4 Drug evaluation– organoleptic, microscopic, chemical, physical and biological, 1.5. Major pharmacological groups of plant drugs and their uses

2. *Secondary metabolites* :

2.1 Definition of secondary metabolites and difference with primary metabolites , 2.2 Interrelationship of basic metabolic pathways with secondary metabolite biosynthesis (outlines only), 2.3 Major types–terpenoids, phenolics, flavonoids, alkaloids and their protective action against pathogenic microbes and herbivores.

3. *Pharmacologically active constituents* :

Source plants (one example) parts used and uses of: 3.1 Steroids (Solasodin, Diosgenin, Digitoxin), 3.2 Tannin (Catechin), 3.3 Resins (Gingerol, Curcuminoids), 3.4 Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine), 3.5. Phenols (Sennocide and Capsaicin).

PAPER VI (THEORETICAL): 100 MARKS: 4 HOURS

Cell Biology	20 Marks (16 Periods)
Plant Breeding & Biometry	15 Marks (12 Periods)
Plant Biotechnology	15 Marks (12 Periods)
Genetics & Molecular Biology	50 Marks (40 Periods)

PAPER VI (THEORETICAL)

CELL BIOLOGY

20 Marks (16 Periods)

1. *Origin and Evolution of Cells :*

1.1. Concept of RNA world, Ribozymes, First cell, 1.2. Origin of eukaryotic cell (endosymbiotic theory), 1.3. Small RNA- ribpswitch, RNA interference, si RNA, mi RNA- brief idea, 1.4. Organellar DNA (cp- and mt- DNA).

2. *Nucleus and Chromosome :*

2.1. Nuclear envelope, Nuclear lamina and Nuclear pore complex, 2.2. Nucleolus-ultrastructure and ribosome biogenesis, 2.3. Chromatin ultrastructure and DNA packaging in eukaryotic chromosome, 2.4. Centromere: types, structure and function.

3. *Cell cycle and its regulation :*

3.1. Kinetochore and spindle apparatus-structural organization and functions, 3.2. Microtubules- structure, organization and function, 3.3. Mechanism of cell cycle control in Yeast (checkpoints and role of MPF), Apoptosis (Brief idea).

PLANT BREEDING & BIOMETRY

15 Marks (12 Periods)

1. *Plant Breeding:*

1.1 Maintenance of germplasm, 1.2. Mass selections and Pure line selection, 1.3. Back cross method, 1.4. Heterosis and hybrid seed production, 1.5. Male sterility and its use in plant breeding, 1.6. Molecular Breeding (use of DNA markers in plant breeding), 1.7. Inbreeding and inbreeding depression, effect of outcrossing- a very brief idea.

2. *Biometry:*

2.1 Data, Sample, Population, Random sampling, Frequency distribution- definition only, 2.2. Central tendency- Arithmetic Mean, Mode and Median, 2.3. Measurement of dispersion – Standard Deviation, Standard error of Mean, Coefficient of variation, 2.4. Test of significance: chi- square test for goodness of fit, 2.5 Probability- multiplicative and additive rules of probability: application and importance, 2.6. Measurement of gene frequency: Hardy-Weinberg equilibrium- conditions applied for its implications (simple problems to calculate genotypic and allelic frequencies).

PLANT BIOTECHNOLOGY

15 Marks (12 Periods)

1. *Plant tissue culture –Introduction:*

1.1. Basic concept and milestones, 1.2. Cellular totipotency, 1.3. Tissue culture media, 1.4. Aseptic manipulation, 1.5. Cyto-differentiation and dedifferentiation.

2. *Callus culture :*

2.1. Callus induction, maintenance and application, 2.2. Suspension culture- introductory idea

3. *Plant regeneration :*

3.1. Organogenesis (direct and indirect), 3.2. Somatic embryogenesis, 3.3. Significance of organogenesis and somatic embryogenesis, 3.4. Artificial seed

4. *Haploid Culture :*

4.1. Anther and Pollen culture methods, 4.2. Significance.

5. *Protoplast Culture :*

5.1. Protoplast isolation and culture, 5.2. Protoplast fusion (somatic hybridization), 5.3. Significance.

6. *Plant Genetic Engineering :*

6.1. Brief concept of different gene transfer methods, special emphasis on *Agrobacterium* mediated gene transfer, Role of Reporter gene, 6.2. Achievements in crop biotechnology, environment and industry (suitable example)- pest resistant plants (BT cotton), herbicide resistance, disease and stress tolerance, transgenic crop with improved quality (flavr tomato, golden rice), role of transgenic in population degradation (super-bug), leaching of minerals, production of industrial enzymes, oil, edible vaccine.

GENETICS & MOLECULAR BIOLOGY

50 Marks (40 Periods)

1. *Linkage, Crossing over and Gene Mapping :*

1.1. Complete and incomplete linkage (example), linked gene does not assort independently (example), linkage group, 1.2. Crossing over, crossing over produces recombination (example), detection of crossing over (McClintock's experiment), and 1.3. Molecular mechanism of crossing over (Holliday model), 1.4. Gene mapping with three point test cross, detection of middle gene in three point test cross, calculation of recombination frequencies, 1.5 Co-efficient of coincidence and interference, Mapping function, 1.6 Problems on gene mapping, 1.7 Molecular mapping – ISH, FISH (brief idea).

2. *Epistasis and Polygenic inheritance* in plants.
3. *Aneuploidy and Polyploidy*: Types, examples, meiotic behaviour and importance of: 3.1. Aneuploidy, 3.2. Polyploidy, 3.2. Speciation and evolution through polyploidy.
4. *Chromosomal aberration*: Types and meiotic behaviour of: 4.1. Deletion, 4.2. Duplication, 4.3. Translocation, and 4.4. Inversion.
5. *Mutation* :
 - 5.1. Point mutation-Transition, Transversion and Frame shift mutation, 5.2. Molecular mechanisms (tautomerisation, alkylation, deamination, base analogue incorporation, dimerisation), 5.3. DNA repair (brief idea).
6. *Structural organisation of Gene* :
 - 6.1. One Gene–one polypeptide concept, 6.2. Split gene, 6.3. Overlapping gene, 6.4. Repetitive DNA-tandem and interspersed, 6.5. Transposon (*Ac-Ds* system), 6.6. Homoeotic gene in plants (ABCE Quartet model of flowering).
7. *DNA Replication, Transcription and Translation (Prokaryotes & Eukaryotes)*:
 - 7.1. Central Dogma, 7.2. Semiconservative DNA replication – *mechanism, enzymes involved in DNA replication- DNA polymerase, DNA gyrase, Helicase, Ligase, primase and other accessory proteins*, 7.3. *Eukaryotic replication with special reference to replication licensing factor, assembly of new nucleosome, replication at the end chromosome telomere, telomerase concept*, 7.4. *Fidelity of DNA replication- prokaryote: nucleotide selection, proof reading, mismatch repair; eukaryote: through selection of error prone DNA polymerase*, 7.5. *Transcription*, 7.6 *RNA processing*, 7.7. *Aminoacylation of tRNA*, 7.8. *Translation*.
8. *Gene Regulation* :
 - 8.1. Concept of *Lac*-operon, 8.2. Positive and negative control.
9. *Genetic Code* :
 - 9.1. Properties-evidences & exceptions, 9.2. Decipherence of codon (Binding technique).
10. *Recombinant DNA Technology*: 10.1. Restriction endonuclease, - types and roles, 10.2. Vector (plasmid pBR 322) 10.3. Marker gene, 10.4. Steps of cloning technique, 10.5. PCR and its application, 10.6. Genomic DNA and cDNA library.
11. Development and causes of Cancer (in general and brief), tumor suppressor gene and oncogene

PAPER VII

(PRACTICAL):75 MARKS 6 HOURS

1. Plant Physiology		20 Marks
2. Plant Biochemistry (Quantitative & Qualitative)	(20+10)=	30 Marks
3. Pharmacognosy		10 Marks
4. Classroom performance: (Attendance and Laboratory records)		
	(3+7) =	10 Marks
5. Viva- voce		5 Marks

PAPER VII (PRACTICAL)

PLANT PHYSIOLOGY

1. Determination of loss of water per stoma per hour.
2. Relationship between transpiration and evaporation.
3. Effect of HCO_3^- concentration on oxygen evolution during photosynthesis in an aquatic plant and to find out the optimum and toxic concentration(either by volume measurement or bubble counting) .
4. Separation of plastidial pigments.
5. Measurement of oxygen uptake by respiring tissue (per g/hr.)
6. Determination of the RQ of germinating seeds.
7. Measurement of osmotic pressure of storage tissue by weighing method.
8. Measurement of osmotic pressure of *Rhoeo* leaf by plasmolytic method.
9. Effect of temperature on absorption of water by storage tissue and determination of Q_{10} .
10. Rate of imbibition of water by starchy, proteinaceous and fatty seeds and effect of seed coat.

PLANT BIOCHEMISTRY

Qualitative:

1. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.
2. Detection of carbohydrate and protein from plant samples.
3. Detection of the nature of carbohydrate – glucose, fructose, sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S and P from plant ash sample.

Quantitative:

1. Preparation of solutions and buffers
2. Estimation of amino-nitrogen by formol titration method (glycine).
3. Estimation of glucose by Benedict's quantitative reagent.
4. Estimation of titratable acidity from lemon and from laboratory sample.
5. Estimation of catalase activity in plant samples.
6. Estimation of urease activity in plant samples.
7. Colorimetric estimation of protein by Folin phenol reagent.

PHARMACOGNOSY

1. Chemical tests for (a) Tannin (*Camellia sinensis* / *Terminalia chebula*), (b) Alkaloid (*Catharanthus roseus*).
2. Powder microscopy – *Zingiber* and *Holarrhena*.
3. Structural identification of different types of pharmaceutically useful starch grains – ginger, arrowroot, maize, wheat and rice,
4. Test for non-lignified vessel (*Zingiber*),

CLASSROOM PERFORMANCE & LABORATORY RECORDS

1. Attendance: A certificate of percentage of attendance in practical classes from the concerned teacher should be attached with lab note books.
2. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes

PAPER VIII (PRACTICAL): 100 MARKS: 6 HOURS

1. Cell Biology and Genetics	(20+10) =	30 Marks
2. Biometry		15 Marks
3. Identification (Cell Biology 4)	(3X4) =	12 Marks
4. Classroom performance (Attendance, Laboratory Records and slides)	(3+3+2) =	8 Marks
5. Review of any topic of interest to the student from any field of botany		5 Marks
6. Viva- voce		5 Marks

PAPER VIII (PRACTICAL)

CELL BIOLOGY AND GENETICS

1. *Introduction to chromosome preparation:* Pre-treatment, Fixation, Staining, Squash and Smear preparation, Preparation of permanent slides.
2. *Determination of mitotic index* and frequency of different mitotic stages in pre-fixed root tips of *Allium cepa*.
3. *Study of mitotic chromosome:* Metaphase chromosome preparation, free hand drawing under high power objective,

- drawing with drawing prism under oil immersion lens, determination of $2n$ number, comment on chromosome morphology of the following specimens from root tips: *Allium cepa*, *Aloe vera*, *Lens esculenta*.
4. *Study of meiotic chromosome*: Smear preparation of meiotic cells, identification of different stages and free hand drawing of the following specimens from flower buds: *Allium cepa* and *Setcreasea* sp.
 5. *Identification from permanent slides*: Meiosis – (i) normal stages (ii) abnormal stages – laggard, anaphase bridge, ring chromosome (*Rhoeo discolor*); Mitosis – (i) normal stages, (ii) abnormal stages- early separation, late separation, multipolarity, sticky bridge, laggard, fragmentation, (ii) pollen mitosis.

BIOMETRY

1. Determination of goodness of fit in normal and modified mono-and dihybrid ratios (3:1, 1:1, 9:7, 13:3, 15:1, 9:3:3:1, 1:1:1:1) by Chi-square analysis and comment on the nature of inheritance.
2. Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (using seedling population / leaflet size).

REVIEW/ PROJECT: on any topic of interest to the student from any field of botany under the supervision of teacher(s) of their college and submit a project/ review report in written form, duly signed by the supervising teacher(s), during the examination. The students may start project/ review work from 2nd year onwards.

CLASSROOM PERFORMANCE & LABORATORY RECORDS

1. Attendance: A certificate of percentage of attendance in practical classes from the concerned teacher should be attached with lab note books.
2. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes.
3. Slides (permanent) prepared during practical classes.

QUESTION PATTERN OF BOTANY (Honours), C.U.

- A-Type-Objective type question each of 1 or 2 marks, no optional question.
B-Type-Short note/ short answer type question each of 5 marks; no part marking.
C-Type-Long answer type question each of 15 marks may be split into 2 to 4 relevant parts, avoiding the pattern of A and B type questions.

Paper-I

Module I (50 Marks).

Q.1. 'A' Type Questions- 10 marks

- (a) Algae-(2x2) + (1x1) = 5
- (b) Microbiology-(2x2) + (1x1) = 5

Q.2. 'B' Type Questions-10 marks

- (a) Algae- (one out of two) - 5x1= 5
- (b) Microbiology – (one out of two) - 5x1= 5

Q.3. 'C' Type Questions-30 marks

(a) Algae- (one out of two) - $15 \times 1 = 15$

(b) Microbiology – (one out of two) - $15 \times 1 = 15$

Module II (50 Marks)

Q.1. 'A' Type Questions- 10 marks

(a) Fungi & Lichen- $(2 \times 2) + (1 \times 1) = 5$

(b) Plant Pathology- $(2 \times 2) + (1 \times 1) = 5$

Q.2. 'B' Type Questions-10 marks

(a) Fungi & Lichen - (one out of two) - $5 \times 1 = 5$

(b) Plant Pathology – (one out of two) - $5 \times 1 = 5$

Q.3. 'C' Type Questions-30 marks

(a) Fungi & Lichen - (one out of two) - $15 \times 1 = 15$

(b) Plant Pathology – (one out of two) - $15 \times 1 = 15$

Paper-IIA

Module III (50 Marks)

Q.1. 'A' Type Questions- 10 marks

(a) Bryophyte- $(2 \times 2) + (1 \times 1) = 5$

(b) Paleobotany & Palynology- $(2 \times 2) + (1 \times 1) = 5$

Q.2. Bryophyte- C Type-15 Marks

Or

B Type- $5 \times 3 = 15$ Marks

Q.3. Paleobotany & Palynology - C Type-15 Marks

Or

B Type- $5 \times 3 = 15$ Marks

Q.4. Embryology - B Type (Two to be answered out of 4) $5 \times 2 = 10$ Marks

Paper-IIB

Module IV (Practical)

Paper-III

Module V (50 Marks)

Q.1. 'A' Type Questions- 10 marks

(a) Anatomy- $(2 \times 2) + (1 \times 1) = 5$

(b) Pteridophytes- $(2 \times 2) + (1 \times 1) = 5$

Q.2. 'B' Type Questions-10 marks

(a) Anatomy- (one out of two) - $5 \times 1 = 5$

(b) Pteridophytes- (one out of two) - $5 \times 1 = 5$

Q.3. 'C' Type Questions-30 marks

(a) Anatomy- (one out of two) - $15 \times 1 = 15$

(b) Pteridophytes - (one out of two) - $15 \times 1 = 15$

Module VI (50 Marks)

Q.1. 'A' Type Questions- 10 marks

(a) Gymnosperms- $(2 \times 2) + (1 \times 1) = 5$

(b) Ecology & Plant Geography- $(2 \times 2) + (1 \times 1) = 5$

Q.2. 'B' Type Questions-20 marks

(a) Gymnosperms- (one out of two) -
 $5 \times 1 = 5$

(b) Ecology & Plant Geography - (one out of two) - $5 \times 1 = 5$

(c) Evolution - (two out of three) - $5 \times 2 = 10$

Q.3. 'C' Type Questions-20 marks

(a) Gymnosperms – (one out of two) - $10 \times 1 = 10$

(b) Ecology & Plant Geography - (one out of two) - $10 \times 1 = 10$

Module VII

Paper-IVA

Paper-IVB

Module VIII (Practical)

Paper-V

Module IX (50 Marks)

1. 'A' Type

Physiology- $(2 \times 4) + (1 \times 2) = 10$ marks

2. 'B' Type (Physiology)
(Two to be answered out of four)- $5 \times 2 = 10$ marks

3. 'C' Type (Physiology)
(Two to be answered out of four)- $15 \times 2 = 30$ marks

Module X (50 Marks)

1. 'A' Type
Biochemistry-(2×4) + (1×2) = 10 marks

2. Biochemistry-'B' Type
(Two to be answered out of four)- $5 \times 2 = 10$ marks

3. Biochemistry-'C' Type
(One to be answered out of two)- $15 \times 1 = 15$ marks

4. Pharmacognosy
C Type-15
marks
Or
B Type- $5 \times 3 = 15$ marks

Paper-VI

Module XI (50

Marks)

1. 'A' Type Questions- 10
marks

- (a) Cell Biology-(2×2) + (1×1) = 5.
(b) Plant Breeding & Biometry-(2×2) + (1×1) = 5.

2. Cell Biology
'C' Type- $15 \times 1 = 15$
marks Or
'B' Type- $5 \times 3 = 15$ marks

3. Plant Breeding & Biometry
'B' Type (Two out of four)- $5 \times 2 = 10$ marks

4. Plant Biotechnology
'C' Type- $15 \times 1 = 15$
marks Or

'B' Type-5x3=15 marks

Module XII (50 Marks)

1. 'A' Type Questions- 10 marks
Genetics & Molecular Biology (2x4)+(1x2)=10
2. 'B' Type -10 Marks
(Two out of four)-5x2=10
3. 'C' Type-30 Marks
(Two out of four)-15x2=30

Suggested Readings

1. General studies

1. Ganguli, H.C., Das, K.S.K. & 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. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency
4. Uno, Storey & Moore, Principles of Botany, 2001, McGraw Hill.
5. Kenrick, P. & Crane, P. The Origin & early diversification of land plants (1997), Smithsonian Institute Press.
6. Bell, P.R. & Hensley, A.R. Green plants; their Origin & Diversity (2nd ed.), 2000, Cambridge University Press
7. Frenkel, T. The origin & early Evolution of life, 2002, Oxford University Press.
8. Hait, G., Ghosh, A. and Bhattacharya, K. A Text Book of Botany (Vols. I, II & III), 2007, New Central Book Agency
9. Lock, A.J., & Evans, D.E., Plant Biology, 2001, Viva Books
10. Chatterjee, T., Santra, S.C. and Das, A. Practical College Botany, New Central Book Agency

2. Algae

1. Kumar, H.D. Introductory Phycology (2nd ed.), 1999, Affiliated East-West Press Pvt. Ltd.
2. Lee, R.E. Phycology (3rd ed.), 1999, Cambridge University Press
3. Vashishta, B.R., Sinha, A.K. & Singh, V.P. Algae (9th ed.), 2002, S. Chand & Company
4. Sambamurty, A.S.S. A text book of Algae, 2005, I.K. International Pvt. Ltd.

5. Graham, L.E. & Wilcox, L.W. Algae, 2000, Prentice Hall
6. Smith, G.M. Cryptogamic Botany, Vol. 1 (2nd ed.), 1955. McGraw Hill
7. Prescott, G.W. Algae: A Review: 1969 Bishen Singh Mahendra Pal Singh
8. Fritsch, F.E. The Structure & Reproduction of Algae, 1936, Vols. I & II, Cambridge University Press
9. Hoek, Van den. Algae, 1995, Cambridge University press
10. Laura De Basanti : Algae, 2004
11. Ray, S. (3rd ed.), Algal Biotechnology Biodiversity, 2010, New Central Book Agency
12. Sharma, O.P. Text Book of Algae, Tata McGraw Hill
13. Ray, S. Algae: Cyanobacteria (2006), New Age International (P) Ltd. Publishers

3. Microbiology

1. Stainer, T.Y., Ingrahm, J.L., Wheelis, M.L. & Painter, P.R. General Microbiology (5th ed.), 1986, Macmillan Educaton Ltd.
2. Dubey, R.C. & Maheswari, D.K. A Text Book of Microbiology, 2005, S.Chand & Company
3. Case. Funke & Tortora, G.J. Microbiology, an Introduction (Latest Ed.)
4. Atlas, R.M. Principles of Microbiology, Latest Ed., McGraw Hill
5. Schlegel, H.G. General Microbiology, Latest Ed., Cambridge University Press
6. Prescott, L.M., Harley,P. & Klein,A. General Microbiogy (5th ed.), 2002, WBC McGraw Hill
7. Sinleton,P. Bacteria; in Biology, Biotechnology and Medicine (5th ed.), 1999, John Wiley & Sons Ltd.
8. Jay, J.M. Modern Food Microbiology (5th ed.), 1996, Chapman & Hall
9. Madigan,M.T., Martinko, J.M. & Parker, J. Brock, Biology of Microorganuisms (10th ed.), 2003, Prentice Hall
10. Hull, R. Matthew Plant Virology (4th ed.), 2002, Academic Press
11. Biswas, S.B. & Biswas, A. An Introduction to Viruses (4th ed.), 1996, Vikas Publishing House
12. Agarwal, A.K. & Parihar, P. Industrial Microbiology, 2005, Agrobios (India)
13. Power, C.B. & Dagimawata, H.F. General Microbiology, Vol. I&II, Himalaya Publishing House
14. Mitchel, R. Environmental Microbiology, Latest Ed. Wiley, N.Y.
15. Sale, A.J. Fundamental Principles of Microbiology, Latest Ed., Tata McGraw Hill
16. Banerjee, A.K. & Banerjee, N. Microbiology & Immunology, 2006, new Central Book Agency
17. Prescott & Dunn. Industrial Microbiology
18. Verma, H.N. Basics of Plant Virology (2003), Oxford and IBH

4. Fungi, Lichen & Plant Pathology

1. Dubey, H.C. An Introduction to Fungi (2nd ed.), 1990, Vikas Publishing House

2. Webster, J. Introduction to Fungi (3rd ed.), Cambridge University Press
3. Alexopoulos, C.J., Mims, C.W. & Blackwell, M. Introductory Mycology (4th ed.), 1996, John Wiley & Sons
4. Hawksworth, D.L. Ainsworth & Bisby Dictionary of Fungi (8th ed.), 1995, Oxford University Press
5. Kavanagh, K. (ed.) Fungi, 2005, Wiley
6. Carlile, M.J., Wilkinson, S.C. & Goodlay, G.W. The Fungi (2nd ed.), 2005, Academic Press
7. Arora, D. (ed.). Hand book of Fungal Biotechnology (2nd ed.), 2003, Dekker, N.Y.
8. Sharma, P.D. Fungi & Allied Organisms, 2005, Narosa Publishing House
9. Deacon, J.W. Fungal Biology, 2006, Black Well Science Ltd.
10. Ingold, C.T. & Hudson, H.J. The Biology of Fungi 96th ed.), 1993, Chapman & Hall
11. Sharma, O.P. Text book of Fungi, Tata McGraw Hill
12. Vashista, B.R. Fungi, Latesgt Ed., S. Chand & Company
13. Chopra, G.L. and Verma, V.A. Text Book of Fungi, Pradeep Publications
14. Liver, R. and Schweizer, M. Molecular Fungal Biology, 1999, Cambridge University Press
15. Dix, N.J. and Webster, J. Fungal Ecology, Chapman & Hall
16. Mehrotra, R.S. and Aneja, K.R. An Introduction to Mycology, Wiley Eastern Ltd.
17. Sharma, P.D. the Fungi, Rastogi Publication
18. Moore Landrecker, E. Fundamentals of the Fungi, Prentice Hall
19. Agrios, G.N. Plant Pathology (5th ed.), 2005, Elsevier, Academic Press
20. Mehrotra, R.S. & Agarwal, A. plant Pathology (2nd ed.), 2003, Tata McGraw Hill
21. Singh, R.S. Principles of Plant Pathology (4th ed.), 2002, oxford & IBH Publishing Com.
22. Manners, J.G. Principles of Plant Pathology (2nd ed.), 1993, Cambridge University Press
23. Trigiano et al. (ed.) Plant Pathology, Concepts and Laboratory exercises, 2004, CRC Press
24. Lucas John, A. Plant Pathology & Plant Pathogen, Oxford
25. Singh, R.S. Plant diseases, Oxford & IBH Publishing Com
26. Rangaswami, G.K. & Mahadevan, A. Diseases of Crop Plants in India, Prentice Hall
27. Dickinson, M. Molecular Plant Pathology, 2003, Bio-Scientific Publishers
28. Isaac, S. Fungal plant Interaction, 1992, Chapman & Hill
29. Bilgrami, K.S. and Dubey, H.C. A TextBook of Modern Plant Pathology, Vikas Publishing House
30. Sharma, P.D. Plant Pathology (2nd ed.), Rastogi Publications
31. Strange, R.N. (ed.) Introduction of plant Pathology, 2003, Wiley
32. Dube, H.C. An Introduction to Fungi (2005), Vikas Publishing House

5. Bryophytes

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
7. Schofield, W.B. Introduction to Bryology, 201, Blackburn Press
8. Smith, A.J.E. (ed.), Bryophyte Ecology, 1982, Chapman & Hall
9. Vanderpoorten & Goffinet, B., Introduction to Bryophytes, 2009, Cambridge university Press

6. Palaeobotany and Palynology

1. Stewart, W.N. & Rothwell, G.W. Palaeobotany & Evolution of Plants, Latest Ed., Cambridge university Press
2. Agashe, S.N. Palaeobotany, Latest Ed., Oxford & IBH
3. Thomas, B.A. & Spicer, R.A. The Evolution & Palaeobotany of Land Plants, Latest Ed., Croomhelm
4. Andrews, H.N. Studies in Palaeobotany, Latest., John Wiley & Sons
5. Meyen, S.V. Fundamentals of Palaeobotany, latest Ed., Chapman & Hill
6. Erdtman, G. pollen Morphology & Plant Taxonomy, Latest Ed., Lelden, E.G. Brill
7. Faegri, K. & Iversen, Text Book of Pollen Analysis, Latest Ed., Munksgor, Copenhagen
8. Nair, P.K. Pollen Morphology of Angiosperms, Latest Ed., Scholar Publications
9. Heslop- Harisson, Pollen: Development & Physiology, Latest Ed., Butterworth
10. Shivanne, K.H. Pollen Biology & Biotechnology, 2003, Oxford & IBH
11. Taylor, T.N. & Taylor, E. N. The Biology & Evolution of Fossil Plants, 1993, Prentice Hall.
12. Willis, K.J. & Mc Elwain, J.C. The Evolution of Plants, 2002, Oxford University Press.
13. Bhattacharya, K., Majumdar, M.R. & Gupta Bhattacharya, S. A Text Book of Palynology, 2006, New Central Book Agency.

7. Embryology

1. Raghavan, V. Molecular Embryology of Flowering Plants, 1997, Camb. University Press.
2. Maheswari, P. An Introduction to Embryology of Angiosperm, Latest Ed., Tata McGraw Hill.
3. Raghavan, V. Embryogenesis in Angiosperms: A Development & Experimental Study, 1986, Cambridge University Press.

4. Bhojwan, S.S. & Bhatnagar, S.D. The Embryology of Angiosperms(4th ed.), 1989, Vikas Publishing House.
5. John, B.M.(ed.). Experimental Embryology of Vascular Plants, 1982, Springer, Heidelberg.
6. Westhaff, P. et al. Molecular Plant Development; From Gene to plant, 1998, Oxford University Press.

8. Pteridophytes

1. Spore, K.R. The Morphology of Pteridophyte, Latest Ed. , Huchinson & Co. Ltd.
2. Rashid, A. An IOntrouduction to Pteridophyta, 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.
5. Mukherjee, R.N. & Chakraborty, K.A. Introduction to Vascular Cryptogams (Pteridophyta) 1995, Kalyani Publications.
6. Parihar, N.S. The Biology & Morphology of Pteridophytes (2nd ed.), 1989, Central Book Distributors.

9. Gymnosperms

1. Sporne, K.R. The Morphology of Gymnosperms, Latest Ed., Hutchinson &Co. Ltd.
2. Vashishta, P.C. Gymnosperm, Latest Ed., S. Chand & Company Pvt.
3. Karkar, R.K. & Karkar, R. The Gymnosperms, Latest Ed.
4. Bhatnagar, S.P. & p.Moitra, A.Gymnosperm, 1997, New Age International
5. Biswas, C. & Johri, P.M. The Gymnosperm, 1997, Narosa Publishing House
6. Dutta, S.C. An Introduction to Gymnosperms (3rd ed.), 1984, Kalyani Publishers
7. Gifford, E.M. and Foster, A.S. Morphology & Evolution of Vascular Plants (3rd ed.), 1989, Freeman & Co.
8. Norstag, J. & Nicholls. T.J. The Biology of the Cycads, 1997, Cornell University Press
9. Friedman, W.E. Biology & Evolution of the Gnetales, 1996, University of Chicago Press

10. Ecology & Plant Geography

1. Chapman and Riss. Ecology: Principles and Applications, Latest Ed., Cambridge University Press
2. Shukla, R.S. & Chandel, P.S. Plant Ecology, Latest Ed., S. Chandel and Co.
3. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House
4. Begon, M., Herper, J.L. and Townsend, C.R. Ecology- Individuals, Populations and Communities (3rd ed.), Oxford Blackwell Science
5. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company
6. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders
7. Sharma, P.D. Elements of Ecology, Latest Ed., Rastogi Publications

8. Ambasht, R.S. & Ambasht, N.K. A Text Book of Plant Ecology, Latest Ed., CBS Publication & Distributors
9. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.
10. Mackenzie et al. Ecology, Latest Ed., Viva Books.
11. Gurevitch, J. (et al.), The Ecology of plants, 2002, Sinauer Associates.
12. Kimar, U. & Asija, M.J. Bio-diversity: Principles & Conservation, 2005, Student Edition, Agrobios (India)
13. Krishnamurthy, K.V. An Advanced Text Book on Biodiversity, 2003, Oxford & IBH Publishing Co. Ltd.
14. Mitra, D., Guha, J.K., Chowdhury, S.K. Studies in Botany, Vol. II (7th ed.) Moulik Library.
15. Primack, R.B. Essentials of Conservation Biology, 1993, Sinauer Associates.
16. Lo, C.P. & Yeung, A.K.W. Concepts and Techniques of Geographic Information Systems, 2002, Printice-Hall of India.
17. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates

11. Evolution

1. Futuyma., D. Evolution. 2015. (3rd Ed.) Sinauer Associates
2. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece. Campbell Biology. 2017. 11th Ed. Pearson

12. Anatomy

1. Fahn, A. Plant Anatomy (4th ed.), 1990, Wiley Eastern.
2. Mauseth, J. D. Plant Anatomy, Latest Ed., Benjamin Cummings Pub.
3. Metcalfe, C.P. & Chalk, L. Anatomy of Dicotyledons, Vol. I & II, London Press, Oxford
4. Dickison, W.C. Integrative Plant Anatomy, 2002, Academic Press
5. Eames, A.J. & Mac. Daniels, L.H. An Introduction to Plant Anatomy, Latest Ed., McGraw Hill
6. Esau, K. Anatomy of Seed Plants (2nd ed.), 1977, John Wiley & Sons
7. Cutter, E.G. Plant Anatomy: Experiment and Interpretations, Part I & II, Edward Arnold
8. Beck, C.B. An Introduction to plant Structure and Development (2nd ed.), Cambridge University Press
9. Howels, S.H. Molecular Genetics of Plant Development, 1998, Cambridge University Press
10. Pandey, B.P. Plant Anatomy, Latest Ed., S. Chand & Company
11. Tayal, M.S. Plant Anatomy, Latest Ed., Rastogi Publications
12. Roy, P. Plant Anatomy, Latest Ed., New Central Book Agency

13. Morphology and Taxonomy of Angiosperms

1. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. Plant Systematics, A Phylogenetic Approach (4th ed.), 2016, Sinauer Associates, Inc.
2. Jones, S.B. and Luchsinger, A.E. Plant Systematics (2nd ed.), 1987, McGraw Hill Book Company
3. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press
4. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
5. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH
6. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House
7. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill
8. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers
9. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press
10. Dutta, S.C. systematic Botany, Latest Ed., Wiley Eastern.
11. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.
12. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.
13. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.
14. Radford. A.B. Fundamentals of Plant Systematics, Latest Ed., Harper & Row.
15. Paria, N.D. and Chattopadhyay, S.P. Flora of Hazaribagh District, Bihar, 2000 & 2001, Vol I & II, BSI, Kolkata
16. Simpson, G. Plant Systematics, 2006, Springer.
17. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.
18. Heywood, V.H. Plant Taxonomy 1967, Edward Arnold, London.
19. Cronquist, A. The Evolution & Classification of Flowering Plant, 1988 (2nd ed.), New York Bot. Garden Bronx. New York.
20. Cronquist, A. An Integrated System of Classification of Flowering Plants. 1981. Bishen Singh Mahendra Pal Singh.
21. Subramanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.
22. Mondal, A. Taxonomy: Advances Plant Taxonomy 2005, New Central Book Agency.
23. Heywood, V.H. Flowering Plants of the World 1978, Oxford University Press.

14. Biochemistry & Plant Physiology

1. Taiz, L., & Zeiger, E. Plant Physiology (4th ed.), 2006, Sinauer Associates, Inc. Publishers.
2. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy. Plant Physiology and Development. (6th ed.) Sinauer Associates.
3. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
4. Jain, V.K. Fundamental of Plant Physiology (7th ed.) 2004. S. Chand and Company.

5. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 1992, Wadsoworth Publishing Company.
6. Panday, S.N. & Sinha, B.K. Plant Physiology (4th ed.), 2006, Vikas Publishing House Pvt. Ltd.
7. Wilkins, M.B. Advances Plant Physiology. 1984, ELBS Longman.
8. Srivastava, L.M. Plant Growth and Development, 2001, Academy Press.
9. Davies P.J. (ed.) Plant Physiology: Physiology, Bio-Chemistry & Molecular Biology, Academic Press.
10. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.
11. Hames, B.D. Bio-Chemistry (2nd ed.) Viva Books.
12. Sackheim, G. Chemistry for Biology Students (5th ed.) 1996, Benjamin/Cummings
13. Raman, H. Transport Phenomenon in Plants, 1997. Narosa Publishing House.
14. Heldt, Hans-Walter. Plant Bio-Chemistry (3rd ed.), 2005. Elsevier Academic Press.
15. Chaudhuri, D., Kar, D.K., and Halder, S.A. Handbook of Plant Biosynthetic Pthways 2008, New Central Book Agencies.
16. Mehta, S.L., Lodha, M.L. & Bane, P.V. Recent Advances in Plant Biochemistry, 1989. I.C.A.R.
17. Conn, E.E. and Stumpf, R.R. Outlines of Bio-Chemistry, Latest Ed., Wiley Eastern.
18. Voet, D. and Voet, J.G., Bio-Chemistry (3rd ed.), 2005, John Wiley & Sons.
19. Mathews, C.K., Van Holder, K.E. & Ahren, K.G. Bio-Chemistry (3rd ed.), 2000, Pearson Education.
20. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson , Michael M. Cox. Freeman, Macmillan.
21. Goodwin, T.W., & Mercer, E.I. Introduction to Plant Biochenistry, Latest Ed., Oxford Pergamon.
22. Berg, J.M., Tymoczko, J.L., & Stryer, L., Bio-Chemistry, Latest Ed., Freeman Publ.
23. Mekee, T. & Mekee, J.R. Bio-Chemistry: The Molecular Basis of Life, 2003, McGraw Hill.
24. Sinha, R.K. Modern Plant Physiology, 2004, Narosa Publishing House.
25. Srivastava, H.S. Plant Physiology (2nd ed.), 1998, Rastogi Publications.
26. Singhal, G.S. Concepts of Photobiology: Photosynthesis & Photomorphogenesis, 1999. Narosa Publishing House.
27. Hall. D.O. & Rao, K.K. photosynthesis (5th ed.), 1995, Cambridge University Press.
28. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.

15. Pharmacognosy

1. Trease & Evans. Pharmacognosy, Saunders.
2. Taylor, V.E., Brady, L.R. and Robbers, J.E. Pharmacognosy, Ind. Ed. K.M. Vergese Co.
3. Wallis, T.E. Text Book of Pharmacognosy, Latest Ed., CBS Publishers & Distributors.

16. Cell Biology, Genetics & Molecular Biology

1. Pierce, Benjamin A. Genetics (2nd ed.), 2005, W.H. Freeman & Company.
2. Atherly, A.G., Girton, J.R. & McDonald, J.F. Science of Genetics, 1999, Saunders College Publications.
3. Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M. & Veres, R.C. Genetics (2nd ed.), 2004, McGraw Hill.
4. Tamarin, Robert H. Principles of Genetic (7th ed., 2002, Tata McGraw Hill.
5. Elrod, S.K. & Stanfield, W. Schuam's Outlines Genetics (4th ed.), 2002, Tata McGraw Hill.
6. Hartl, D.L. & Jones, E.W. Genetics , 2005, Jones & Barlett Publishers.
7. Lewin, B. Genes VIII, 2004, Pearson Educational International.
8. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. & Losick, R. Molecular Biology of the Gene (5th ed.) 2004. Pearson Education Inc.
9. Griffiths, A.I.F., Miller, J.H., Suzuki, D.T., Lewentin, C.R. & Gilbert, M.W. An Introduction to Genetic Analysis, 2005 (8th ed.), W.H. Freeman & Company.
10. Brown, T.A. Genomes, 1999, John Wiley & Sons.
11. Brown, T.A. Genomes 3, 2007, Garland Science Publishing.
12. Snustad, D.P. & Simmons, M.J. Principles of Genetics (2nd ed.), 2000, (4th ed.), 2006, John Wiley & Sons.
13. Klug, W.S. & Cummings, M.R. Concepts of Genetics, 2003, Pearson Education.
14. Gerald Karp. Cell Biology. 2013. 7th Ed. International Student Version. Wiley.
15. Hawkins, J.D. Gene Structure & Expression (3rd ed.), 1996, Cambridge University Press.
16. Becker, M.W., Klemsmith, L.J. & Hardin, J. The World of the Cell (5th ed.), 2003, Pearson Education.
17. Cooper, G.M. The Cell, A molecular approach (2nd ed.), 2000, ASM Press.
18. Weaver, R.F. Molecular Biology (2nd ed./3rd ed.), 2002/2005, McGraw Hill.
19. Malacinski, G.M. Freifelder, Essentials of Molecular Biology (4th ed.), 2003, Narosa Publishing House.
20. Sambamurty, A.V.S.S. Genetics (2nd ed.), 2005, Narosa publishing House.
21. Sharma, A. & Sen, S. Chromosome Botany, 2002, Oxford & IBH Publishing.
22. Sen, S. & Kar, D.K. Cytology & Genetics, 2005, Narosa Publishing House.
23. Miglani. G.S. Advanced Genetics, 2002, Narosa Publishing House.
24. Gupta, P.K. Genetics, 2007, Rastogi Publications.
25. De Robertis, E.D.P. & De Robertis, E.M.M, Cell & Molecular Biology (8th ed.), 1987, Informed Limited.
26. Sharma, A.K. and Sharma, A. Chromosome Technique, 1980, Butterworth Publications.
27. Strickberg, M.W. Genetics, McMillan.
28. Jain, H.K. Genetics, 1999, Oxford & IBH Publishing Company.
29. Swanson, C.P., Merz, T. & Young, W.J. Cytogenetics, 1981, Prentice Hall.
30. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. & Walter, P. Molecular Biology of the Cell, 2002 (4th ed.), Garland Sciences.

31. Gardner, E.J., Simmons, M.J. & Snustad, D.P. Principles of Genetics (8th ed.) 1991, John Wiley & Sons.
32. Twyman, R.M. Gene Transfer to Plant Bios.
33. Gregory, T.R. The Evolution of the Genome, 2005, Elsevier.
34. Russel, P.J. Fundamental of Genetics (2nd ed.), 2000, Pearson Education.
35. Sinnott, E.W., Dunn, L.C. & Dobzhansky, T. Principles of Genetics (5th ed.) 1958, Tata McGraw Hill.
36. Old, R.W. & Primrose, S.B. Principles of Gene Manipulation, 1989, Blackwell Scientific Publications.
37. Kar, D.K. and Halder, S. Cell Biology, Genetics and Molecular Biology 2008, New Central Book Agency.
38. Roy, S.C. and De, K.K. Cell Biology, 1997, New Central Book Agency.
39. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell. 2015. 6th Ed: Garland Science.
40. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. Molecular Cell Biology. 2013. 8th Ed. Freeman.

17. Plant Breeding & Biometry

1. Chaudhuri, H.K. Elementary Principles of Plant Breeding, Latest Ed., Oxford & IBH.
2. Allaed, R.W. Principles of Plant Breeding, 1960, John Wiley & Sons.
3. Poehlman, J.M. & Barthakur, D. Plant Breeding, Latest Ed., Oxford & IBH.
4. Singh, B.D. Plant Breeding, Principles & Methods (7th ed.), 2005, Kalyani Publishers.
5. Barley, N.T.J. Statistical Methods in Biology, Latest Ed., Cambridge University Press.
6. Roy, D. Plant Breeding: Analysis & Exploitation of Variation, 2000, Narosa Publishing House.
7. Zar, J.H. Biostatistical Analysis (3rd ed.), 1996, Prentice Hall.
8. Kar, D.K. and Halder, S. Plant Breeding & Biometry, 2006, New Central Book Agency.
9. Dutta, Animesh K. Basic Biostatistics & its Application 2006, New Central Book Agency.

18. Plant Biotechnology

1. Chawla, H.S. An Introduction to Plant Biotechnology (2nd ed.), 2002, Oxford & IBH
2. Borer, A., Sentos, F.R. & Bowen, D.B. Understanding Biotechnology, 2003, Pearson Education
3. Ingacimuthu, S. Plant Biotechnology, 1997, Oxford & IBH
4. Walker, J.M. & Rapley, R. Molecular Biology & Biotechnology, 2000, Royal Society of Chemistry
5. Collin, H.A. and Edwards, S. Plant Cell Culture, 1998, Bios Scientific Publishers
6. Dixon, R.A. & Gonzales, R. A. Plant Cell Culture: A Practical Approach, 1994, Oxford University Press

7. Gamorgs, O.L. & Phillips, G.C. Plant Cell, Tissue and Organ Culture: Fundamental method, Narosa Publishing House
8. Dubey, R.C. Biotechnology, Latest Ed., S.Chand & Company Pvt. Ltd.
9. Bhojwani, S.S. & Razdan, M.I. Plant Tissue Culture: Theory and Practise, Elsevier
10. Rajdan, M.K. An Introduction to Plant Tissue Culture, Latest Ed., Oxford & IBH
11. Jha, T.B. & Ghosh, B. Plant Tissue Culture, 2003, Universities Press
12. Singh, B.D. Biotechnology Latest ed., Kalyani Publishers.
13. Mascarenhas, A.F. Handbook of Plant Tissue Culture, ICAR
14. Kar, D.K. & Halder, S. Plant Breeding, Biometry & Biotechnology, 2010, New Central Book Agency
15. Gupta, P.K. Biotechnology & Genomes, latest Ed., Rastogi Publications
16. Slatter, A., Scott, N. & Fowler, N. Plant Biotechnology, 2003, Oxford University Press
17. Dey, K.K. Plant Tissue Culture, 1992, New Central Book Agency