



UNIVERSITY OF CALCUTTA

Notification No. CSR/ 12 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 28.05.2018 (vide Item No.14) approved the Syllabi of different subjects in Undergraduate Honours / General / Major courses of studies (CBCS) under this University, as laid down in the accompanying pamphlet:

List of the subjects

<u>Sl. No.</u>	<u>Subject</u>	<u>Sl. No.</u>	<u>Subject</u>
1	Anthropology (Honours / General)	29	Mathematics (Honours / General)
2	Arabic (Honours / General)	30	Microbiology (Honours / General)
3	Persian (Honours / General)	31	Mol. Biology (General)
4	Bengali (Honours / General /LCC2 /AECC1)	32	Philosophy (Honours / General)
5	Bio-Chemistry (Honours / General)	33	Physical Education (General)
6	Botany (Honours / General)	34	Physics (Honours / General)
7	Chemistry (Honours / General)	35	Physiology (Honours / General)
8	Computer Science (Honours / General)	36	Political Science (Honours / General)
9	Defence Studies (General)	37	Psychology (Honours / General)
10	Economics (Honours / General)	38	Sanskrit (Honours / General)
11	Education (Honours / General)	39	Social Science (General)
12	Electronics (Honours / General)	40	Sociology (Honours / General)
13	English ((Honours / General/ LCC1/ LCC2/AECC1)	41	Statistics (Honours / General)
14	Environmental Science (Honours / General)	42	Urdu (Honours / General /LCC2 /AECC1)
15	Environmental Studies (AECC2)	43	Women Studies (General)
16	Film Studies (General)	44	Zoology (Honours / General)
17	Food Nutrition (Honours / General)	45	Industrial Fish and Fisheries – IFFV (Major)
18	French (General)	46	Sericulture – SRTV (Major)
19	Geography (Honours / General)	47	Computer Applications – CMAV (Major)
20	Geology (Honours / General)	48	Tourism and Travel Management – TTMV (Major)
21	Hindi (Honours / General /LCC2 /AECC1)	49	Advertising Sales Promotion and Sales Management –ASPV (Major)
22	History (Honours / General)	50	Communicative English –CMEV (Major)
23	Islamic History Culture (Honours / General)	51	Clinical Nutrition and Dietetics CNDV (Major)
24	Home Science Extension Education (General)	52	Bachelor of Business Administration (BBA) (Honours)
25	House Hold Art (General)	53	Bachelor of Fashion and Apparel Design – (B.F.A.D.) (Honours)
26	Human Development (Honours / General)	54	Bachelor of Fine Art (B.F.A.) (Honours)
27	Human Rights (General)	55	B. Music (Honours / General) and Music (General)
28	Journalism and Mass Communication (Honours / General)		

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 4th June, 2018

Paul
4/6/18
(Dr. Santanu Paul)
Deputy Registrar

UNIVERSITY OF CALCUTTA

SYLLABUS

FOR

THREE-YEAR B.Sc. HONOURS COURSE

UNDER CHOICE BASED CREDIT SYSTEM



BOTANY

FOR SESSION 2018-2019

Core courses (CC-Total 14 courses to be studied in semesters. All theoretical papers i.e., BOT-A...TH are of 4 credits each and the respective practical papers i.e., BOT-A....P of 2 credits each)

SEM I:

1. Phycology and Microbiology (BOT-A-CC-1-1-TH, BOT-A-CC-1-1-P)
2. Mycology and Phytopathology (BOT-A-CC-1-2-TH, BOT-A-CC-1-2-P)

SEM II

3. Plant anatomy (BOT-A-CC-2-3-TH, BOT-A-CC-2-3-P)
4. Archegoniate (BOT-A-CC-2-4-TH, BOT-A-CC-2-4-P)

SEM III

5. Palaeobotany and Palynology (BOT-A-CC-3-5-TH, BOT-A-CC-3-5-P)
6. Reproductive biology of Angiosperms (BOT-A-CC-3-6-TH, BOT-A-CC-3-6-P)
7. Plant systematic (BOT-A-CC-3-7-TH, BOT-A-CC-3-7-P)

SEM IV

8. Plant geography, Ecology and Evolution (BOT-A-CC-4-8-TH, BOT-A-CC-4-8-P)
9. Economic Botany (BOT-A-CC-4-9-TH, BOT-A-CC-4-9-P)
10. Genetics (BOT-A-CC-4-10-TH, BOT-A-CC-4-10-P)

SEM V

11. Cell and Molecular biology (BOT-A-CC-5-11-TH, BOT-A-CC-5-11-P)
12. Biochemistry (BOT-A-CC-5-12-TH, BOT-A-CC-5-12-P)

SEM VI

13. Plant Physiology (BOT-A-CC-6-13-TH, BOT-A-CC-6-13-P)
14. Plant Metabolism (BOT-A-CC-6-14-TH, BOT-A-CC-6-14-P)

Skill enhancement courses (SEC- 2, two papers to be selected from the list taking 1 from SEC A in 3rd SEM and 1 from SEC B in 4th SEM. Both the papers of 2 credits each and theoretical only)

SEC A (SEM III)

1. Applied Phycology, Mycology and Microbiology (BOT-A-SEC-A-3-1)
2. Biofertilizers (BOT-A-SEC-A-3-2)

SEC B (SEM IV)

3. Plant Breeding (BOT-A-SEC-B-4-3)
4. Mushroom Culture Technology (BOT-A-SEC-B-4-4)

Discipline specific elective courses (DSE, four courses to be selected from the 2 groups (A & B). A student shall choose any one paper from each of Group- A and Group- B in 5th AND 6th SEM. Each course comprises of theoretical component of 4 credits and practical ones of 2 credits)

DSE-A (Group- A)

SEM V

1. Biostatistics (BOT-A-DSE-A-5-1-TH, BOT-A-DSE-A-5-1-P)
2. Industrial and Environmental Biology (BOT-A-DSE-A-5-2-TH, BOT-A-DSE-A-5-2-P)

SEM VI

3. Medicinal and Ethnobotany (BOT-A-DSE-A-6-3-TH, BOT-A-DSE-A-6-3-P)
4. Stress Biology (BOT-A-DSE-A-6-4-TH, BOT-A-DSE-A-6-4-P)

DSE-B (Group-B)

SEM V

5. Plant Biotechnology (BOT-A-DSE-B-5-5-TH, BOT-A-DSE-B-5-5-P)
6. Horticultural practices and Post Harvest Technology (BOT-A-DSE-B-5-6-TH, BOT-A-DSE-B-5-6-P)

SEM VI

7. Research Methodology (BOT-A-DSE-B6-7-TH, BOT-A-DSE-B-6-7-P)
8. Natural resource management (BOT-A-DSE-B-6-8-TH, BOT-A-DSE-B-6-8-P)

DISSERTATION/PROJECT: A Dissertation / Project may be given in lieu of a DSE. This is considered as a special course and will be of 6 credits. (Vide page 4 of CUS/268(CIR/18, dated 07.05.2018)). However, the details of the topics, modalities of evaluation etc. to be notified latter on.

SEME STER	COURSE OPTED	COURSE NAME	CREDIT
I	Core Course 1- BOT-A-CC-1-1-TH	Phycology and microbiology	4
	Core Course 1- BOT-A-CC-1-1-P	Phycology and microbiology Practical	2
	Core Course 2- BOT-A-CC-1-2-TH	Mycology and phytopathology	4
	Core Course 2- BOT-A-CC-1-2-P	Mycology and phytopathology Practical	2
II	Core Course 3- BOT-A-CC-2-3-TH	Plant anatomy	4
	Core Course 3- BOT-A-CC-2-3-P	Plant anatomy Practical	2
	Core Course 4- BOT-A-CC-2-4-TH	Archegoniate	4
	Core Course 4- BOT-A-CC-2-4-P	Archegoniate Practical	2
III	Core Course 5- BOT-A-CC-3-5-TH	Palaeobotany and palynology	4
	Core Course 5- BOT-A-CC-3-5-P	Palaeobotany and palynology Practical	2
	Core Course 6- BOT-A-CC-3-6-TH	Reproductive biology of angiosperms	4
	Core Course 6- BOT-A-CC-3-6-P	Reproductive biology of angiosperms Practical	2
	Core Course 7- BOT-A-CC-3-7-TH	Plant systematics	4
	Core Course 7- BOT-A-CC-3-7-P	Plant systematics Practical	2
	SEC A – BOT-A-SEC-A-3-1/ BOT-A-SEC-A-3-2	Only ONE paper to be selected	2
IV	Core Course 8- BOT-A-CC-4-8-TH	Plant geography, ecology and evolution	4
	Core Course 8- BOT-A-CC-4-8-P	Plant geography, ecology and evolution Practical	2
	Core Course 9- BOT-A-CC-4-9-TH	Economic botany	4
	Core Course 9- BOT-A-CC-4-9-P	Economic botany Practical	2
	Core Course 10- BOT-A-CC-4-10-TH	Genetics	4
	Core Course 10- BOT-A-CC-4-10-P	Genetics Practical	2
	SEC B – BOT-A-SEC-B-4-3/ BOT-A-SEC-B-4-4	Only ONE paper to be selected	2
V	Core Course 11- BOT-A-CC-5-11-TH	Cell and molecular biology	4
	Core Course 11- BOT-A-CC-5-11-P	Cell and molecular biology Practical	2
	Core Course 12- BOT-A-CC-5-12-TH	Biochemistry	4
	Core Course 12- BOT-A-CC-5-12-P	Biochemistry Practical	2
	DSE A: BOT-A-DSE-A-5-1 & 2-TH & P	Only ONE paper to be selected from Group A	4 & 2
	DSE B: BOT-A-DSE-B-5-5 & 6-TH & P	Only ONE paper to be selected from Group B	4 & 2

VI	Core Course 13- BOT-A-CC-6-13-TH	Plant physiology	4
	Core Course 13- BOT-A-CC-6-13-P	Plant physiology practical	2
	Core Course 14- BOT-A-CC-6-14-TH	Plant metabolism	4
	Core Course 14- BOT-A-CC-6-14-P	Plant metabolism Practical	2
	DSE A: BOT-A-DSE-A-6-3&4-TH & P	Only ONE paper to be selected Group A	4 & 2
	DSE B: BOT-A-DSE-B-6-7&8 -TH & P	Only ONE paper to be selected Group B	4 & 2

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

SEMESTER I

CORE COURSE 1

PHYCOLOGY AND MICROBIOLOGY (BOT-A-CC-1-1-TH)

THEORETICAL

(Credits 4, Lectures-60)

PHYCOLOGY

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, 1.5. Significant contributions of important phycologists (Fritsch, Smith, R. N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar)

.....5 lectures

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.

.....5 lectures

3. Cyanobacteria:

3.1. Ultrastructure of cell, 3.2. Heterocyst - structure and function, 3.3. Ecology.

.....4 lectures

4. Bacillariophyta:

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

.....6 lectures

5. Life History:

5.1. *Chlamydomonas*, 5.2. *Oedogonium*, 5.3. *Chara*, 5.4. *Ectocarpus*, 5.5. *Polysiphonia*, 5.6. Evolutionary significance of *Prochloron*.

.....10 lectures

MICROBIOLOGY

1. Virus:

1.1. Discovery, 1.2. Plant virus- types, 1.3. Transmission and translocation of Plant virus, 1.4. TMV-

Physicochemical characteristics and Multiplication, 1.5. One step growth curve, 1.6. Lytic cycle (T4 phage) and Lysogenic cycle (Lambda phage), Significance of lysogeny, 1.7. Viroids and Prions.

.....10 lectures

2. Bacteria:

2.1. Discovery, 2.2. Distinguishing features of Archaea and Bacteria, 2.3. Characteristics of some major groups: Proteobacteria (Enterobacteria), Firmicutes, Mollicutes, Actinobacteria, Spirochaetes, Chlamydiae, 2.4. Bacterial growth curve and generation time, 2.5. Flagella (ultrastructure) & Pili, 2.6. Cell wall – chemical structure and differences between Gram +ve & Gram – ve bacteria, 2.7. Bacterial genome and plasmid, 2.8. Endospore - formation, structure and function, 2.9. Genetic Recombination (a) Transformation – with special emphasis on Natural and Induced competence and DNA uptake, (b) Conjugation– F- factor, $F^+ \times F^-$, Hfr $\times F^-$, concept of F', chromosome mobilization, (c) Transduction– Generalised and specialized.

.....20 lectures

PRACTICAL- PHYCOLOGY AND MICROBIOLOGY (BOT-A-CC-1-1-P) (Credits 2)

1. Work out: Algae, Bacterial staining
2. Identification with reasons: (Algae and bacteria)
3. Classroom performance (Lab notebook, submission and permanent slides)
4. Viva- voce

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 : *Gloetrichia*, *Volvox*, *Vaucheria*, *Coleochaete*, *Polysiphonia*, Centric and Pennate diatom; (b) Macroscopic specimens : *Laminaria*, *Sargassum*.

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.

FIELD WORK

At least one local excursion to be conducted for study and collection of algae (only 5 from natural habitat) and another local excursion should be conducted to give an introductory idea about plant diversity (Collection not required).

CLASSROOM PERFORMANCE

1. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes.
2. Slides (permanent) prepared during practical classes.
3. Submission (5 algae collected from natural habitat and identified latter)

CORE COURSE 2
MYCOLOGY AND PHYTO-PATHOLOGY (BOT-A-CC-1-2-TH)
THEORETICAL
(Credits 4, Lectures 60)

MYCOLOGY

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.

.....6 lectures

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.

.....6 lectures

3. Life history:

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

.....10 lectures

4. Mycorrhiza:

4.1. Types with salient features, 4.2. Role in Agriculture & Forestry.

.....4 lectures

5. Lichen:

5.1. Types, 6.2. Reproduction, 6.3. Economic and ecological importance

.....4 lectures

PHYTO-PATHOLOGY

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).

.....6 lectures

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.

.....6 lectures

3. Plant Disease Management :

3.1. Quarantine, 3.2. Chemical, 3.3. Biological, 3.4. Integrated.

.....8 lectures

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.

.....10 lectures

PRACTICAL- MYCOLOGY AND PHYTO-PATHOLOGY (BOT-A-CC-1-2-P)

(Credits 2)

MYCOLOGY

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).

PHYTO- 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 macrofungi (only 5).

CLASSROOM PERFORMANCE

1. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes

2. Slides (permanent) prepared during practical classes.

3. Submission (5 Macro fungi)

SEMESTER- II

CORE COURSE 3

PLANT ANATOMY (BOT-A-CC-2-3-TH)

(Credits 4, Lectures 60)

ANATOMY

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.

.....8 lectures

2. Stomata:

2.1. Types (Metcalf and Chalk, Stebbins and Khush).

.....4 lectures

3. Stele:

3.1 Leaf-trace and leaf-gap, 3.2. Stellar types & evolution

.....4 lectures

4.Primary structure of stem and root- Monocot and Dicot. Leaf- dorsiventral and isobilateral.

.....8 lectures

5. Secondary growth:

5.1. Normal (intra- & extra-stelar), 5.2. Anomalous (stem of *Bignonia*, *Boerhavia*, *Tecoma*, *Dracaena* and root of *Tinospora*).

.....12 lectures

6. Mechanical tissues and the Principles governing their distribution in plants.

.....8 lectures

7. Developmental Anatomy:

7.1. Organisation of shoot apex (Tunica–Corpus) and Root apex (Körper-Kappe), 7.2. Plastochrone.

.....8 lectures

8. Ecological Anatomy:

Adaptive anatomical features of 8.1. Hydrophytes, 8.2. Xerophytes.

.....4 lectures

9. Scope of plant anatomy: application in systematics, forensics and pharmacognosy.

.....4 lectures

PRACTICAL- PLANT ANATOMY (BOT-A-CC-2-3-P)

(Credits 2)

1.Workout on Plant Anatomy

2. Identification with reasons

3.Classroom performance: (Lab records, slides)

4. Viva

PLANT 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 anatomical details through permanent slides/ temporary stained mounts- a) Root- Monocot and dicot, b) Stem- Monocot and dicot, c) Leaf- Monocot and dicot.
3. Study of anomalous secondary structure in stem of *Bignonia*, *Boerhaavia*, *Tecoma*, *Dracaena* and root of *Tinospora*
4. Study of adaptive anatomical features: Hydrophytes (*Nymphaea* – petiole) and Xerophytes (*Nerium* – leaf).

CORE COURSE 4
ARCHAEGONIATE (BOT-A-CC-2-4-TH)
THEORITICAL
(Credits 4, Lectures 60)

BRYOPHYTES

1. General Account :

1.1. General characteristics and adaptations to land habit, 1.2. Classification (Strotler and Crandle Strotler, 2009) up to class with diagnostic characters and examples.

.....4 lectures

2. Life History: Gametophyte structure and Reproduction, Development and Structure of sporophyte, Spore dispersal in:

2.1. *Marchantia*, 2.2. *Anthoceros*, 2.3. *Funaria*.

.....6 lectures

3. Phylogeny:

3.1. Unifying features of archaegoniates; transition to land habit, 3.2. Origin of Alternation of Generations (Homologous and Antithetic theory), 3.3. Evolution of Sporophytes (Progressive and Regressive concept), 3.4. Origin of Bryophytes.

.....4 lectures

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*.

.....2 lectures

PTERIDOPHYTES

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.

.....4 lectures

2. Life History:

Sporophyte structure, Reproduction and Structure of gametophyte in 2.1. *Psilotum*, 2.2. *Selaginella*, 2.3. *Equisetum*, 2.4. *Pteris*.

.....8 lectures

3. Telome concept and its significance in the origin of different groups of Pteridophytes.

.....4 lectures

4. Heterospory and Origin of Seed habit.

.....4 lectures

5. Economic importance as food, medicine and Agriculture.

.....2 lectures

GYMNOSPERMS

1. Classification of vascular plants by Gifford & Foster (1989) upto division (Progymnospermophyta to Gnetophyta) with diagnostic characters and examples.

.....4 lectures

2. Progymnosperms :

Diagnostic characters of the group, 2.2. Vegetative and reproductive features of Archeopteris, 2.3. Phylogenetic importance.

.....6 lectures

3. Life History :

Distribution in India; Vegetative and Reproductive structure of sporophyte, Development of gametophyte in : 3.1. *Cycas* , 3.2. *Pinus* and 3.3. *Gnetum*.

.....8 lectures

4. Economic Importance with reference to Wood, Resins, Essential oils, and Drugs.

.....4 lectures

PRACTICAL- ARCHAEGONIATE (BOT-A-CC-2-4-P)
(Credits 2)

1. Workout on Pteridophytes
2. Identification with reasons (Bryophytes, Pteridophytes and Gymnosperms)
3. Classroom performance: (Lab records, slides)
4. Field report
5. Viva

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).

PTERIDOPHYTES

1. Morphological study of the sporophytic plant body: Genera as mentioned in the theoretical syllabus and *Lycopodium*, *Ophioglossum* and *Marsilea*.
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).

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).

FIELD STUDY

Botanical excursion to familiarize the students with the natural habitats of these groups is desirable. No individual collection should be allowed. Students should submit only photographs in their field report.

SEMESTER- III
CORE COURSE-5
PALAEOBOTANY AND PALYNOLOGY (BOT-A-CC-3-5-TH)
THEORETICAL
(Credits 4, Lectures 60)

PALAEOBOTANY & PALYNOLOGY

1. Geological time scale with dominant plant groups through ages.

.....4 lectures

2. Plant Fossil:

2.1. Types: Body fossil (Micro- and Megafossils), Trace fossil, Chemical fossil, Index fossil, 2.2. Different modes of preservation (Schopf, 1975), 2.3. Conditions favouring fossilization, 2.4. Nomenclature and Reconstruction, 2.5. Principle of fossil dating (a brief idea), 2.6. Importance of fossil study.

.....12 lectures

3. Fossil Pteridophytes:

Structural features, Geological distribution and Evolutionary significance of 3.1. *Rhynia*, 3.2. *Lepidodendron* (Reconstructed), 3.3. *Calamites* (Reconstructed).

.....10 lectures

4. Fossil gymnosperms:

Structural features and Geological distribution of reconstructed genera: 4.1. *Lyginopteris*, 4.2. *Williamsonia*, 4.3. *Cordaites*.

.....10 lectures

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

.....6 lectures

6. Palynology:

6.1. Spore and Pollen, 6.2. Pollen aperture types, 6.3. NPC classification (Erdtman). 6.4. Pollen wall- Sporopollenin, Stratification and Ornamentation (sculpturing).

.....10 lectures

7. Applied Palynology:

Basic concepts of: 7.1. Palaeopalynology, 7.2. Aeropalynology, 7.3. Forensic palynology, 7.4. Melissopalynology.

.....8 lectures

PRACTICAL- PALAEOBOTANY AND PALYNOLOGY (BOT-A-CC-3-5-P)
(Credits 2)

1. Study from permanent preparations
2. Identification with reasons
3. Classroom performance: (Lab records)
4. Viva

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. Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes.

CORE COURSE- 6
REPRODUCTIVE BIOLOGY OF ANGIOSPERMS (BOT-A-CC-3-6-TH)
THEORETICAL
(Credits 4, Lectures 60)

MORPHOLOGY OF ANGIOSPERMS

1. Inflorescence types with examples.
.....8 lectures
2. Flower, induction of flowering, flower development- genetic and molecular aspects.
.....14 lectures
3. Fruits and seeds - types with examples.
.....8 lectures

EMBRYOLOGY

1. Pre-fertilisation changes :

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

.....6 lectures

2. Fertilisation:

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

.....6 lectures

3. Post-fertilization changes :

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

.....10 lectures

4. Apomixis & Polyembryony:

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

.....8 lectures

PRACTICAL- REPRODUCTIVE BIOLOGY OF ANGIOSPERMS (BOT-A-CC-3-6-P)

(Credits 2)

1. Identification with reasons (Morphology)
2. Classroom performance: (Lab records)
3. Field Records (Field note book/ project work)
4. Viva

REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

1. Inflorescence types- study from fresh/ preserved specimens
2. Flowers- study of different types from fresh/ preserved specimens
3. Fruits- study from different types from fresh/preserved specimens
4. Study of ovules (permanent slides/ specimens/photographs)- types (anatropous, orthotropous, amphitropous and campylotropous)
5. Field study desirable
6. A project supported along with photographs taken during field study to be submitted giving comprehensive idea about different types of inflorescence, flowers and fruits.

CLASSROOM PERFORMANCE

Same as above.

CORE COURSE- 7
PLANT SYSTEMATICS (BOT-A-CC-3-7-TH)
THEORETICAL
(Credits 4, Lectures 60)

TAXONOMY OF ANGIOSPERMS

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.

.....6 lectures

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.

.....6 lectures

3. Systems of classification:

Broad outline of Bentham & Hooker (1862-1883), Cronquist (1988), Takhtajan (1991) - system of classification with merits and demerits. Brief reference of angiosperm phylogeny group (APG III) classification.

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); 3.2. Dichotomous keys – indented and bracketed.

.....20 lectures

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.

.....8 lectures

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).

.....8 lectures

6. Diagnostic features, Systematic position (Bentham & Hooker and Cronquist), Economically important plants (parts used and uses) of the following families:

6.1. Monocotyledons: Alismataceae, Gramineae (Poaceae), Cyperaceae, Palmae (Arecaceae), Liliaceae, Musaceae, Zingiberaceae, Cannaceae, Orchidaceae.

6.2. Dicotyledons: Nymphaeaceae, Magnoliaceae, Leguminosae (subfamilies), Polygonaceae, Euphorbiaceae, Malvaceae, Umbelliferae (Apiaceae), Labiatae (Lamiaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Compositae (Asteraceae).

.....12 lectures

PRACTICAL- PLANT SYSTEMATICS (BOT-A-CC-3-7-P)
(Credits 2)

1. Workout on Angiosperms
2. Spot Identification
3. Classroom performance: (Lab records)
4. Field Records (Field note book, Herbarium specimens)
5. Viva

ANGIOSPERMS

1. Work out, description, preparation of floral formula and floral diagram, identification up to genus with the help of suitable literature of wild plants and systematic position according to Bentham Hooker system of classification from the following families: Malvaceae, Fabaceae (Papilionaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.
2. Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus (list to be provided).

FIELD WORK

At least three excursions including one excursion to Acharya Jagadish Chandra Bose Indian Botanic Garden (Shibpur, Howrah) and Central National Herbarium (CNH).

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 during examination.

CLASSROOM PERFORMANCE

Same as above.

SEMESTER IV
CORE COURSE-8
PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION (BOT-A-CC-4-8-TH)
THEORETICAL
(Credits 4, Lectures 60)

PLANT GEOGRAPHY

1. Phytogeographical regions:

1.1. Phytogeographical regions of India (Chatterjee 1960); 1.2. Dominant flora of Eastern Himalaya, Western Himalaya and Sunderban.

.....8 lectures

2. Endemism:

2.1 Endemic types and Factors; 2.2. Age & Area hypothesis and Epibiotic theory; 2.3. Endemism in Indian flora.

.....6 lectures

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.

.....4 lectures

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.

.....6 lectures

3.1. Plant indicators (metallophytes); 3.2. Phytoremediation.

.....4 lectures

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
.....16 lectures

EVOLUTION

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
.....6 lectures

2.1 Brief idea on: Stabilizing directional, disruptive and sexual selection; Speciation: Sympatric and allopatric speciation; Coevolution, Adaptive radiation, Reproductive isolation
.....4 lectures

3.1. Simplified phylogeny of bacteria, algae, fungi, bryophyte, pteridophyte and gymnosperm, 3.2. Phylogenetic tree.
.....6 lectures

PRACTICAL- PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION (BOT-A-CC-4-8-P) (Credits 2)

1. Workout on ecological parameters
2. Classroom performance: (Lab records)
3. Field Records (Field note book of phytogeographical study and ecological study)
4. Viva

PLANT GEOGRAPHY

1. Field visit- at least one long excursion at different phytogeographical region of India.
2. Study of local flora and submission of a project report highlighting phytogeographical characteristics of the region.

ECOLOGY

1. 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 visit).
2. Comparative anatomical studies of leaves from polluted and less polluted areas.
3. Measurement of dissolved O₂ by azide modification of Winkler's method.
4. Comparison of free CO₂ from different sources.

CORE COURSE- 9
ECONOMIC BOTANY (BOT-A-CC-4-9-TH)
THEORETICAL
(Credits 4, Lectures 60)

1. Origin of cultivated crops: Concepts of centre of origin, their importance with reference to Vavilov's work. Examples of major plant introductions; crop domestication and loss of genetic diversity; evolution of new crops/ varieties, importance of germplasm diversity.
.....6 lectures
2. Cereals: Rice and wheat (origin, morphology, processing and uses).
.....6 lectures
3. Legumes: Origin, morphology and uses of gram and mung bean. Importance to man and environment.
.....6 lectures
4. Sugar and starches: Morphology and processing of sugarcane, products and byproducts of sugarcane industry. Potato- morphology, propagation and uses.
.....5 lectures
5. Spices: Listing of important spices, their family and part used.
.....6 lectures
6. Beverages: Tea (morphology, processing and uses).
.....5 lectures
7. Oil and fats: General description, classification, extraction, their uses and health implications of mustard, soybean, coconut (Botanical name, family and uses). Essential oils- general account, extraction methods, comparison with fatty oils and their uses.
.....10 lectures
8. Drug-yielding plants: Therapeutic and habit forming drugs with special reference to Cinchona, Digitalis, Papavar, Cannabis and Tobacco (morphology, processing, uses and health hazards).
.....8 lectures
9. Timber: general account with special reference to Sal and Teak.
.....4 lectures
10. Fibers: Cotton and Jute (Morphology, extraction and uses).
.....4 lectures

PRACTICAL- ECONOMIC BOTANY (BOT-A-CC-4-9-P)
(Credits 2)

1. Workout, micro-chemical tests
2. Identification- T.S./L.S. of permanent slides

3. Classroom performance: (Lab records, permanent slides)
4. Field visit desirable to give an idea about cultivation of any crop (viz. rice, jute, mustard, tea, potato)
5. Field record of the visit, properly authenticated by escorting teacher

ECONOMIC BOTANY

1. Cereals: Wheat (habit sketch, L.S./T.S. of grain, starch grains, micro-chemical tests); rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests)
2. Legume: Soybean, ground nut (habit, fruit, seed structure, micro-chemical tests)
3. Source of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); potato (habit sketch, tuber morphology, T.S. of tuber to show localization of starch grains, W.M. of starch grains, micro-chemical tests.
4. Tea- tea leaves, tests for tannin
5. Mustard- plant specimen, seeds, tests for fat in crushed seeds
6. Habit sketch of *Digitalis*, *Papaver* and *Cannabis*.
7. Sal, Teak- section of young stem.
8. Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fibre following maceration technique.

**CORE COURSE 10
GENETICS (BOT-A-CC-4-10-TH)
THEORETICAL
(Credits 4, Lectures 60)**

1. Introduction: Mendelian genetics and its extension

.....6 lectures

2. Linkage, Crossing over and Gene Mapping:

2.1. Complete and incomplete linkage (example), linked gene does not assort independently (example), linkage group, 2.2. Crossing over, crossing over produces recombination (example), detection of crossing over (McClintock's experiment), and 2.3. Molecular mechanism of crossing over (Holliday model), 2.4. Gene mapping with three point test cross, detection of middle gene in three point test cross, calculation of recombination frequencies, 2.5. Co-efficient of coincidence and

interference, mapping function, 2.6. Problems on gene mapping, 2.7. Molecular mapping – ISH, FISH (brief idea).

.....16 lectures

3. Epistasis and Polygenic inheritance in plants.

.....4 lectures

4. Aneuploidy and Polyploidy: Types, examples, meiotic behaviour and importance of: 4.1. Aneuploidy, 4.2. Polyploidy, 4.3. Speciation and evolution through polyploidy.

.....8 lectures

5. Chromosomal aberration: Types and meiotic behaviour of: 5.1. Deletion, 5.2. Duplication, 5.3. Translocation, and 5.4. Inversion.

.....6 lectures

6. Mutation :

6.1. Point mutation-Transition, Transversion and Frame shift mutation, 6.2. Molecular mechanisms (tautomerisation, alkylation, deamination, base analogue incorporation, dimerisation), 6.3. DNA repair (brief idea).

.....8 lectures

7. Structural organisation of Gene:

7.1. One Gene–one polypeptide concept, 7.2. Split gene, 7.3. Overlapping gene, 7.4. Repetitive DNA-tandem and interspersed, 7.5. Transposon (Ac-Ds system), 7.6. Homoeotic gene in plants (ABCE Quartet model of flowering).

.....12 lectures

PRACTICAL- GENETICS (BOT-A-CC-4-10-P)

(Credits 2)

1. Genetics
2. Identification
3. Classroom performance (Laboratory Records and slides)
- 4 Viva- voce

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, and comment on chromosome morphology of the following specimens from root tips:**

Allium cepa, Aloe vera, Lens esculenta.

4. Study of chromosomal aberrations developed due to exposure to any two pollutants/ pesticides etc.

5. 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.

6. 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.

SEMESTER V

CORE COURSE- 11

CELL AND MOLECULAR BIOLOGY (BOT-A-CC-5-11-TH)

THEORETICAL

(Credits 4, Lectures 60)

CELL BIOLOGY

1. Origin and Evolution of Cells:

1.1. Evolution of nucleic acid (from PNA to DNA), Concept of RNA world, Ribozymes, First cell, 1.2. Origin of eukaryotic cell (endosymbiotic theory), 1.3. Small RNA- riboswitch, RNA interference, si RNA, mi RNA- brief idea, 1.4. Organellar DNA (cp- and mt- DNA).

.....6 lectures

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.

.....6 lectures

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).

.....6 lectures

MOLECULAR BIOLOGY

1. DNA Replication, Transcription and Translation (Prokaryotes & Eukaryotes):

1.1. Central Dogma, 1.2. Semiconservative DNA replication – mechanism, enzymes involved in DNA replication- DNA polymerase, DNA gyrase, Helicase, Ligase, primase and other accessory proteins, 1.3. Eukaryotic replication with special reference to replication licensing factor, assembly of new nucleosome, replication at the end chromosome telomere, telomerase concept, 1.4. Fidelity of DNA replication- prokaryote: nucleotide selection, proof reading, mismatch repair; eukaryote: through selection of error prone DNA polymerase, 1.5. Transcription, 1.6 RNA processing, 1.7. Aminoacylation of tRNA, 1.8. Translation.

.....20 lectures

2. Gene Regulation:

2.1 Concept of Lac-operon, 2.2. Positive and negative control.

.....4 lectures

3. Genetic Code:

3.1 Properties-evidences & exceptions, 3.2. Decipherance of codon (Binding technique).

.....4 lectures

4. Recombinant DNA Technology:

4.1. Restriction endonuclease, - types and roles, 4.2. Vector (plasmid pBR 322), 4.3. Marker gene, 4.4. Steps of cloning technique, 4.5. PCR and its application, 4.6. Genomic DNA and cDNA library.

.....10 lectures

5. Development and causes of Cancer (in general and brief), tumor suppressor gene and oncogene.

.....4 lectures

PRACTICAL- CELL BIOLOGY (BOT-A-CC-5-11-P)

(Credits 2)

1. Work out
2. Identification
3. Classroom performance (Laboratory Records and slides)
4. Preparation of models/charts
5. Viva-voce

CELL BIOLOGY

1. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo/Crinum*
2. Measurement of cell size by the technique of micrometry.
3. Counting cells per unit volume with the help of haemocytometer (Yeast/pollen grains)
4. Cytochemical staining of DNA- Pyronine-methyl green staining.

5. Estimation of DNA content through DPA staining.
6. Estimation of RNA through orcinol method.
7. Study of nucleolus through hematoxylin/ orcin staining and determination of nucleolar frequency.
8. Preparation of models/ charts: rolling circle, theta replication, semi-discontinuous replication, prokaryotic RNA polymerase and eukaryotic RNA polymerase II, assembly of spliceosome machinery, splicing mechanism in group I and group II introns, ribozyme and alternative splicing.

CORE COURSE- 12
BIOCHEMISTRY (BOT-A-CC-5-12-TH)
THEORETICAL
(Credits 4, Lectures 60)

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.

.....6 lectures

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.

.....24 lectures

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.

.....18 lectures

4. Cell membrane:

4.1. Membrane chemistry, 4.2. Membrane transport (uniport, symport, antiport), mechanism of ion

uptake.

.....6 lectures

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

.....6 lectures

PRACTICAL- BIOCHEMISTRY (BOT-A-CC-5-12-P)
(Credits 2)

1. Workout on Plant Biochemistry (Quantitative & Qualitative)
2. Classroom performance (Laboratory Records and slides)
3. Viva

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 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 Benedicts quantitative reagent.
4. Estimation of titratable acidity from lemon.
5. Estimation of catalase activity in plant samples and effect of substrate, enzyme concentration and pH on enzyme activity.
6. Estimation of urease activity in plant samples.
7. Colorimetric estimation of protein by Folin phenol reagent.

SEMESTER VI
CORE COURSE-13
PLANT PHYSIOLOGY (BOT-A-CC-6-13-TH)
THEORETICAL (Credits 4, Lectures 60)

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.

.....6 lectures

2. Mineral nutrition: essential and beneficial elements, macro- and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

.....6 lectures

3. Organic Translocation:

3.1. Phloem sap, P-protein, 3.2. Phloem loading and unloading, 3.3. Mass-flow (pressure flow) hypothesis and its critical evaluation.

.....6 lectures

4. Plant Growth Regulators:

4.1. Physiological roles of Auxin, Gibberellin, Cytokinin, Abscisic acid, Ethylene, 4.2. Chemical nature – IAA, GA₃, Kinetin, 4.3. Biosynthesis and bioassay of IAA, 4.4. Mode of action of IAA, 4.5. Brassinosteroids and Polyamines as PGRs (brief idea).

.....18 lectures

5. Photomorphogenesis:

5.1. Concept of photomorphogenesis, 5.2. Photoperiodism and plant types, 5.3. Perception of photoperiodic stimulus, 5.4. Critical day length, concept of light monitoring, 5.5. Phytochrome, cryptochrome and phototropins- chemical nature and role in photomorphogenesis, 5.6. Role of GA in flowering, 5.7. Vernalisation – role of low temperature in flowering, 5.8. Concept of biological clock and biorhythm.

.....12 lectures

6. Seed dormancy: 6.1. Types, Causes and Methods of breaking seed dormancy, 6.2. Biochemistry of seed germination.

.....6 lectures

7. Physiology of Senescence and Ageing.

.....6 lectures

PRACTICAL- PLANT PHYSIOLOGY (BOT-A-CC-6-13-P)
(Credits 2)

1. Plant Physiology
2. Classroom performance (Laboratory records)
3. Viva- voce

PLANT PHYSIOLOGY

1. Determination of loss of water per stoma per hour.
2. Relationship between transpiration and evaporation.
3. Measurement of osmotic pressure of storage tissue by weighing method.
4. Measurement of osmotic pressure of *Rhoeo* leaf by plasmolytic method.
5. Effect of temperature on absorption of water by storage tissue and determination of Q_{10} .
6. Rate of imbibition of water by starchy, proteinaceous and fatty seeds and effect of seed coat.
7. To study the phenomenon of seed germination (effect of light).
8. To study the induction of amylase activity in germinating grains.
9. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA bioassay)

CORE COURSE 14
PLANT METABOLISM (BOT-A-CC-6-14-TH)
THEORETICAL
(Credits 4, Lectures 60)

1. Concept of metabolism: Introduction, Anabolic and catabolic metabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and isozymes)

.....4 lectures

2. Photosynthesis:

- 2.1. Chemical structure of chlorophyll a and b, absorption and action spectra, biological significance of carotenoid pigments, 2.2. Red drop and Emerson effect, Components of photosystems (light harvesting complex), photochemical reaction centres, Cyclic and noncyclic electron transport, Water splitting mechanism, 2.3. Calvin cycle – Biochemical reactions & stoichiometry, 2.4. HSK Pathway– three variants of the pathway, 2.5. Photosynthetic efficiency of C_3 and C_4 plants and crop

productivity, 2.6. Photorespiration – mechanism and significance, 2.7. Crassulacean Acid Metabolism– mechanism and ecological significance.

.....16 lectures

3. Respiration:

3.1. EMP pathway, regulation and its anabolic role, 3.2. Conversion of Pyruvic acid to Acetyl CoA, 3.3. TCA-cycle and its amphibolic role, 3.4. Oxidative pentose phosphate pathway and its significance, 3.5. Mitochondrial electron transport system, uncouplers, 3.6. Oxidation of cytosolic $\text{NADH}+\text{H}^+$, 3.7. Stoichiometry of glucose oxidation (aerobic).

.....12 lectures

4. Nitrogen Metabolism:

4.1. Assimilation of nitrate by plants, 4.2. Biochemistry of dinitrogen fixation in Rhizobium, 4.3. General principle of amino acid biosynthesis (including GS and GOGAT enzyme system).

.....10 lectures

5. Lipid metabolism:

5.1. synthesis and breakdown of triglycerides, β -oxidation, glyoxalate cycle, gluconeogenesis and its role in mobilization of the lipids during seed germinbations, α - oxidation.

.....8 lectures

6. Mechanism of signal transduction: receptor-ligand interactions, second messenger concept, calcium-calmodilin, G protein, MAP-kinase cascade.

.....10 lectures

PRACTICAL- PLANT METABOLISM (BOT-A-CC-6-14-P) (Credits 2)

1. Workout on Plant metabolism
2. Classroom performance (Laboratory Records)
3. Viva

PLANT METABOLISM

1. A basic idea of chromatography: Principle, paper chromatography and column chromatography; demonstration of column chromatography.
2. Separation of plastidial pigments by solvent and paper chromatography.
3. Estimation of total chlorophyll content from different chronologically aged leaves (young, mature and senescence) by Arnon method.

4. Effect of HCO₃ 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).
5. Measurement of oxygen uptake by respiring tissue (per g/hr.)
- 6.. Determination of the RQ of germinating seeds.
7. Test of seed viability by TTC method.

SKILL ENHANCEMENT COURSE- ELECTIVE (SEC)

SEC-A

APPLIED PHYCOLOGY, MYCOLOGY AND MICROBIOLOGY (BOT-A-SEC-A-3-1)

THEORETICAL

(Credits 2, Lectures 30)

APPLIED PHYCOLOGY

1. Algae as food and source of phycocolloid (Agar-agar, Algin, Carrageenan), 2. Diatomite, 3. Algal toxin, 4. Algal Biotechnology – potential of microalgae for SCP, β-carotene, Biodiesel, bioplastics from algae.

.....10 lectures

APPLIED MYCOLOGY

1. Fungi as food, 2. Cheese and Ethanol- Industrial production (brief outline), 3. Fungal sources and uses of Enzyme (Cellulase), Amino acid (Tryptophan), Vitamin (Riboflavin), Antibiotic (Griseofulvin), Pharmaceuticals (Cyclosporin-A). 4. Aflatoxin

.....10 lectures

APPLIED MICROBIOLOGY

1. Industrial Production of Vinegar and Streptomycin (brief outline), 2. Microbial sources and uses of Enzyme (Amylase, Protease), Amino acid (Glutamic acid, Lysine), Polysaccharides (Dextran), 3. Use of microbes as Biofertilizer and Biopesticides, 3.4. Use of microbes in mineral processing.

.....10 lectures

BIOFERTILIZERS (BOT-A-SEC-A-3-2)

THEORETICAL

(Credits 2, Lectures 30)

1. General account about the microbes used as biofertilizers- *Rhizobium*- isolation, identification, mass multiplication, carrier based inoculants, actinorrhizal symbiosis.
2. *Azospirillum*: isolation and mass multiplication- carrier based inoculants, associative effect of different microorganisms.

.....4 lectures

.....4 lectures

3. **Azotobacter:** classification, characteristics- crop response to *Azetobacter* inoculants, maintenance and mass multiplication.
.....4 lectures
4. Cyanobacteria (Blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation. Factors affecting growth, blue green algae and *Azolla* in rice cultivation.
.....4 lectures
5. *Mycorrhizal* association, types of mycorrhizal association, phosphorus nutrition, growth and yield- colonisation of VAM – isolation and inoculum production of VAM and its influence on growth and yield of crop plants.
.....8 lectures
6. **Organic farming-** green manuring and organic fertilizers, recycling of biodegradable municipal, agricultural and industrial wastes- biocompost making methods, types and methods of vermicomposting- field application.
.....6 lectures

SEC-B

PLANT BREEDING (BOT-A-SEC-B-4-3)

THEORITICAL

(Credits 2, Lectures 30)

1. **Plant breeding:** introduction and objectives, breeding systems- modes of reproduction in crop plants, important achievements and undesirable consequence of plant breeding.
.....4 lectures
2. **Methods of crop improvement:** Introduction- centres of origin and domestication of crop plants, plant genetics resources; acclimatization, selection methods- for self pollination, cross pollinated and vegetatively propagated plants, hybridization- for self, cross and vegetatively propagated plants, procedure, advantages and limitations.
.....6 lectures
3. Maintenance of germplasm, 3.1. Mass selections and Pure line selection, 3.2. Back cross method.
.....6 lectures
4. Heterosis and hybrid seed production, 4.1. Male sterility and its use in plant breeding.
.....2 lectures
5. Inbreeding and inbreeding depression, effect of outcrossing- a very brief idea.
.....4 lectures
6. Molecular Breeding (use of DNA markers in plant breeding).
.....2 lectures
7. Role of mutations, polyploidy, distant hybridization and role of biotechnology in crop improvements.
.....6 lectures

MUSHROOM CULTURE TECHNOLOGY (BOT-A-SEC-B-4-4)

THEORETICAL

(Credits 2, Lecture 30)

1. Introduction, nutritional and medicinal value of edible mushrooms; poisonous mushrooms, types of edible mushrooms available in India- *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*.
.....5 lectures
2. **Cultivation technology:** infrastructure: substrates (locally available), polythene bags, vessels, inoculation hook, inoculation loop, low cost stoves, sieves, culture racks, mushroom unit (thatched house), water sprayer, tray, small polythene bag. Pure culture: medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation- paddy straw, sugarcane trash, maize straw, banana leaves,. Factors affecting the mushroom bed preparation- low cost technology, composting technology in mushroom production.
.....12 lectures
3. **Storage and nutrition:** short term storage (Refrigeration- upto 24 hours), long term storage (canning, pickles, papads), drying, storage in salt solutions. Nutrition- proteins- amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.
.....8 lectures
4. **Food preparation:** type of foods prepared from mushroom. Research centres- National level and regional level. Cost benefit ratio- marketing in India and abroad. Export value.
.....5 lectures

DISCIPLINE SPECIFIC ELECTIVE COURSES

DSE-A

BIOSTATISTICS (BOT-A-DSE-A-5-1-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. **Biostatistics:** Definition, statistical methods, basic principles, variables- measurements, functions, limitations and uses of statistics.
.....12 lectures
2. **Biometry:** Data, Sample, Population, Random sampling, Frequency distribution- definition only.
.....12 lectures
3. **Central tendency**– Arithmetic Mean, Mode and Median; Measurement of dispersion–

Coefficient of variation, Standard Deviation, Standard error of Mean.

.....10 lectures

4. Test of significance: chi- square test for goodness of fit.

.....6 lectures

5. Probability- multiplicative and additive rules of probability: application and importance.

.....6 lectures

6. Measurement of gene frequency: Hardy-Weinberg equilibrium- conditions applied for its implications (simple problems to calculate genotypic and allelic frequencies).

.....14 lectures

PRACTICAL- BIOSTATISTICS (BOT-A-DSE-A-5-1-P)

(Credits 2)

1. Workout
2. Classroom performance (Laboratory Records)
3. Viva

BIOSTATISTICS

1. Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (using seedling population / leaflet size).
2. Calculation of correlation coefficient values and finding out the probability.
3. Determination of goodness of fit in Mendellian and modified mono-and dihybrid ratios (3:1, 1:1, 9:3:3:1, 1:1:1:1, 9:7, 13:3, 15:1) by Chi-square analysis and comment on the nature of inheritance.
4. Calculation of 'F' value and finding out the probability value for the F value
5. Basic idea of computer programme for statistical analysis of correlation coefficient, 't' test, standard error, standard deviation.

INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY (BOT-A-DSE-A-5-2-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Scope of microbes in industry and environment.

.....6 lectures

2. Bioreactors/ Fermenters and fermentation process: solid- state and liquid-state (stationary and submerged) fermentations; batch and continuous fermentations. Components of a typical

bioreactors, types of bioreactors- laboratory, pilot scale and production fermenters. Constantly stirred fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air- lift Fermenter.

.....12 lectures

3. Microbial production of industrial products: microorganisms involved, media, fermentation conditions, down stream processing and uses; filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, liophilisation, spray drying, hands on microbial fermentations for the production and estimation of enzymes amylase or lipase activity, organic acids (citric or glutamic acid), alcohol (ethanol) and antibiotic (Penicillin).

.....12 lectures

4. Microbial enzymes of industrial interest and enzyme immobilization: microorganisms for industrial applications. Methods of immobilization, advantages and applications of immobilization, large scale application of immobilized enzymes (glucose isomerase and penicillin acylase).

.....8 lectures

5. Microbes and quality of environment: distribution of microbes in air, isolation of microorganisms from soil, air and water.

.....8 lectures

6. Microbial flora of water: water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD of water samples. Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.

.....8 lectures

7. Microbes in agriculture and remediation of contaminated soils: biological fixation, mycorrhizae, bioremediation of contaminated soils, isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

.....8 lectures

PRACTICAL- INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY (BOT-A-DSE-A-5-2-P)

(Credits 2)

1. Workout
2. Classroom performance (Laboratory Records)
3. Viva

INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

1. Principals and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Preparation of slant, stab and pouring petriplate.

4. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

MEDICINAL AND ETHNOBOTANY (BOT-A-DSE-A-6-3-TH)
THEORETICAL
(Credits 4, Lectures 60)

1. Medicinal botany: History, scope and importance of medicinal plant, a brief idea about indigenous medicinal sciences- ayurveda, siddha and unani. Polyherbal formulations.

.....14 lectures

2. Pharmacognosy- General account :

2.1 Pharmacognosy and its importance in modern medicine, 2.2 Crude drugs, 2.3 Classification of drugs- chemical and pharmacological, 2.4 Drug evaluation– organoleptic, microscopic, chemical, physical and biological, 2.5. Major pharmacological groups of plant drugs and their uses.

.....12 lectures

3. Secondary metabolites:

3.1 Definition of secondary metabolites and difference with primary metabolites , 3.2 Interrelationship of basic metabolic pathways with secondary metabolite biosynthesis (outlines only), 3.3 Major types–terpenoids, phenolics, flavonoids, alkaloids and their protective action against pathogenic microbes and herbivores.

.....14 lectures

4. 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).

.....4 lectures

5. Ethnobotany and folk medicine: Definition, methods of study, application, Indian scenario, national interacts, Palaeo-ethnobotany, folk medicines in ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India, application of natural products to certain diseases- Jaudice, cardiac, infertility, diabetics, blood pressure and skin diseases.

.....16 lectures

PRACTICAL- MEDICINAL AND ETHNOBOTANY (BOT-A-DSE-A-6-3-P)
(Credits 2)

1. Workout and chemical tests

2. Classroom performance (Laboratory Records)
3. Viva

MEDICINAL AND ETHNOBOTANY

1. Chemical tests for (a) Tannin (*Camellia sinensis* / *Terminalia chebula*), (b) Alkaloid (*Catharanthus roseus*) .
2. Powder microscopy – *Zingiber* and *Holarrhena* .
3. Histochemical tests of (a) Curcumin (*Curcuma longa*), (b) Starch in non-lignified vessel (*Zingiber*), (c) Alkaloid (stem of *Catharanthus* and bark of *Holarrhena*).

STRESS BIOLOGY (BOT-A-DSE-A-6-4-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Plant stress- definition. Acclimation and adaptation.2 lectures
2. Environmental factors- water stress, salinity stress and temperature stress- plant response. Pathogenesis- related (PR) proteins, systemic acquired resistance; mediation of insect and disease resistance by jasmonates.20 lectures
3. Stress sensing mechanism in plants: calcium modulation, phospholipid signaling.20 lectures
4. Developmental and physiological mechanisms that protect plants against environmental stress: adaptation of plants, changes in root-shoot ratios, aerenchyma development; osmotic adjustment, compatible solute production.12 lectures
5. Reactive oxygen species- production and scavenging mechanism.6 lectures

PRACTICAL- STRESS BIOLOGY (BOT-A-DSE-A-6-4-P)

(Credits 2)

1. Workout
2. Classroom performance (Laboratory Records)
3. Viva

STRESS BIOLOGY

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide dismutase activity in the absence and presence of stress.
3. Catalase activity in the presence and absence of stress.
4. Comparative study of plants/seedlings subjected to different degree of stress/ pollutants.
5. To study the effect of stress (salt/ water/ heavy metal) on seed germination and seedling growth (any commonly available specimen)

DSE-B

PLANT BIOTECHNOLOGY (BOT-A-DSE-B-5-5-TH)

THEORETICAL

(Credits 4, Lectures 60)

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.

.....10 lectures

2. Callus culture:

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

.....6 lectures

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.

.....8 lectures

4. Haploid Culture:

- 4.1. Anther and Pollen culture methods, 4.2. Applications.

.....6 lectures

5. Protoplast Culture:

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

.....6 lectures

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.

.....24 lectures

PRACTICAL- PLANT BIOTECHNOLOGY (BOT-A-DSE-B-5-5-P)
(Credits 2)

1. Field report on a visit to a tissue culture lab.
2. Classroom performance (Laboratory Records, charts/ models)
3. Viva

PLANT BIOTECHNOLOGY

1. Familiarization of basic equipments in plant tissue culture
2. Study through photographs/ charts/ models of anther culture, somatic embryogenesis, endosperm and embryo culture, micropropagation.
3. Preparation of basal media. Sterilization techniques.
4. Demonstration of any tissue culture technique during visit in a plant tissue culture lab.

DSE B

HORTICULTURAL PRACTICES AND POST- HARVEST TECHNOLOGY (BOT-A-DSE-B-5-6-TH)
THEORETICAL
(Credits 4, Lectures 60)

1. **Horticulture** –scope, importance and branches. Role in rural economy and employment generation; importance in food and nutritional security; urban horticulture and ecotourism.
.....4 lectures
2. **Ornamental plants:** types, classifications (annuals, perennials, climbers and trees), identification and salient features of some ornamental plants (rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulants). Ornamental flowering trees (Indian laburnum, gulmohor, jacaranda, Lagerostoemia, fishtail and Erica palms, simul, coral tree).
.....4 lectures
3. **Fruit and vegetable crops:** production, origin and distribution; description of plants and their

economic products; management and marketing of vegetables and fruit crops; identification of some fruits and some vegetables varieties (citrus, banana, mango, chillis and cucurbits).

.....4 lectures

- 4. Horticultural techniques:** application manures, fertilizers, nutrients and PGRs; weed controls, biofertilizers, biopesticides, irrigation methods. Hydroponics, propagation methods; vegetative (grafting, cutting, layering, budding), sexual (seed production), scope and limitations.

.....8 lectures

- 5. Landscaping and garden designing:** planning and lay out (parks and gardens).

.....6 lectures

- 6. Floriculture:** cut flowers, bonsai, commerce (market demand and supply), importance of flower shows and exhibitions.

.....6 lectures

- 7. Post harvest technology:** Importance of post harvest technology in horticultural crops, evaluation of quality, traits; harvesting and handling of fruits, vegetables, cut flower; principles, methods of preservation and processing, methods of minimizing losses during storage and transportation; food irradiation- advantages and disadvantages; food safety.

.....10 lectures

- 8. Disease control and management:** field and post harvest diseases, identification of deficiency symptoms, remedial measures and nutritional management practices; crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); quarantine practices; identification of common diseases and pest of ornamental fruits and vegetable crops.

.....8 lectures

- 9. Horticultural crops-** conservation and management: documentation and conservation of germplasm. Role of micropropagation and tissue culture techniques; varieties and cultivars of various horticultural crops; IPR issues, national international and professional societies and sources of information on horticulture.

.....10 lectures

**PRACTICAL- HORTICULTURAL PRACTICES AND POST- HARVEST TECHNOLOGY (BOT-A-DSE-B-5-6-P)
(Credits 2)**

Field trip- field visits to gardens, standing crop sites, nurseries, vegetable gardens, horticultural fields at IARI/AHSI or other suitable locations and if possible to cold storage.

RESEARCH METHODOLOGY (BOT-A-DSE-B-6-7-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Basic concepts of research: research- definition and types of research (Descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical), research methods vs. methodology; literature- review and its consolidation; library research; field research; laboratory research.
.....10 lectures
2. General laboratory techniques: common calculations in botany laboratories; understanding the details on the label of reagent bottles; molarity and normality of common amino acids and bases; preparation of solutions. Dilution, percentage, molar, molal and normal solutions. Techniques of handling micropipettes; knowledge about common toxic chemicals and safety measures in their handling.
.....12 lectures
3. Data collection and documentation of observations. Maintaining of laboratory records, tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.
.....6 lectures
4. Overview of biological problems: plant science research key areas, model organisms in research.
.....6 lectures
5. Methods to study plant cells/ tissue structure: whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning, tissue preparation- fixation, dehydration etc., paraffin and plastic infiltration, preparation of thin and ultra-thin sections.
.....6 lectures
6. Plant micro-techniques: staining procedures, classification and chemistry of stains, staining equipments. Cytogenetic techniques with squashed plant materials.
.....12 lectures
7. The art of scientific writing and its presentation: numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power point presentation. Poster presentation. Scientific writing ethics. Introduction to copy write- academic misconduct/ plagiarism.
.....8 lectures

PRACTICAL- RESEARCH METHODOLOGY (BOT-A-DSE-B-6-7-P)

(Credits 2)

1. Experiments based on calculations
2. Plant microtechnique experiments

3. The art of imaging of samples through photomicrography and field photography
4. Poster/ power point presentation on defined topics
5. Technical writing on topics assigned.

Natural resource management (BOT-A-DSE-B-6-8-TH)

THEORETICAL

(Credits 4, Lectures 60)

Unit 1: Natural resources

Definition and types.

..... 2 lectures

Unit 2: Sustainable utilization

Concept, approaches (economic, ecological and socio-cultural).

..... 8 lectures

Unit 3: Land

Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.

..... 8 lectures

Unit 4: Water

Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.

..... 8 lectures

Unit 5: Biological Resources

Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

..... 12 lectures

Unit 6: Forests

Definition, Cover and its significance (with special reference to India); Major and minor Forest products; Depletion; Management.

..... 6 lectures

Unit 7: Energy

Renewable and non-renewable sources of energy.

..... 6 lectures

Unit 8: Contemporary practices in resource management

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

..... 8 lectures

Unit 9: National and international efforts in resource management and conservation

..... 4 lectures

PRACTICAL- Natural resource management (BOT-A-DSE-B-6-8-P)
(Credits 2)

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Estimation of foliar dust deposition.
3. Determination of total solid in water (TDS)
4. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)
5. Estimation of organic carbon percentage present in soil sample.
6. Collection of data on forest cover of specific area.

REFERENCES

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. 22
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 Education 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 Microbiology (5th ed.), 2002, WBC McGraw Hill
7. Singleton, 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 Microorganisms (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. Mitchell, 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 23
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, Latest 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 Introduction 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. Sambamurthy, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
5. Sivarajan, 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, Wadsworth 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 Intrduction 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, Naroas 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

19. Natural resource management

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

UNIVERSITY OF CALCUTTA
SYLLABUS
FOR
THREE-YEAR B.Sc. PROGRAMME IN
BOTANY (GENERAL COURSE)
UNDER CHOICE BASED CREDIT SYSTEM



BOTANY

Syllabus for three-year B.Sc. Botany Programme
(With effect from 2018-2019)

CORE COURSES (4)

Each theoretical course of 4 credits and practical of 2 credits.

1. Plant diversity I (Phycology, Mycology, Phytopathology, Bryophytes and Anatomy) – a) Theoretical- BOT-G-CC-1-1-TH b) Practical- BOT-G-CC-1-1-P (... .. GE-1-1-TH & P)

2. Plant diversity II (Pteridophytes, Gymnosperms, Palaeobotany, Morphology and Taxonomy) – a) Theoretical- BOT-G-CC-2-2-TH b) Practical- BOT-G-CC-2-2-P (... .. GE-2-2-TH & P)

3. Cell biology, Genetics and Microbiology – a) Theoretical- BOT-G-CC-3-3-TH b) Practical- BOT-G-CC-3-3-P (... .. GE-3-3-TH & P)

4. Plant physiology and metabolism – a) Theoretical- BOT-G-CC-4-4-TH b) Practical- BOT-G-CC-4-4-P (... .. GE-4-4-TH & P)

N.B.: The above said four core courses (CC) may be considered as GE 1, 2, 3 & 4 respectively for the honours students of other allied disciplines opting Botany as one of the general courses.

Skill enhancement courses (SEC, four courses to be selected strictly on 2 subjects out of 3 subjects opted taking 2 courses from each subject. Each general subject shall have 2 groups (A & B) of SEC papers. One paper from Group A from each of the 2 subjects to be chosen in the 3rd and 5th Semester, one paper from Group B of each of the 2 subjects to be chosen in the 4th and 6th Semesters. Each paper of 2 credits and theoretical only)

SEC A

1. Plant breeding and biometry (BOT-G-SEC-A-3/5-1)
2. Biofertilizers (BOT-G-SEC-A-3/5-2)

SEC B

1. Plant biotechnology (BOT-G-SEC-B-4/6-3)
2. Mushroom culture technology (BOT-G-SEC-B-4/6-4)

Discipline specific elective courses (DSE, two courses to be selected from the list taking one each from Group A in 5th semester and one from Group B in 6th Semester. Each course comprises of theoretical component of 4 credits and practical ones of 2 credits)

DSE A

1. Phytochemistry and medicinal botany- a) Theoretical- BOT-G-DSE-A-5-1-TH, b) Practical- BOT-G-DSE-A-5-1-P
2. Natural resource management- a) Theoretical- BOT-G-DSE-A-5-2-TH, b) Practical- BOT-G-DSE-A-5-2-P

DSE B

3. Economic botany- a) Theoretical- BOT-G-DSE-B-6-3-TH, b) Practical- BOT-G-DSE-B-6-3-P
4. Horticultural practices and post harvest technology - a) Theoretical- BOT-G-DSE-B-6-4-TH, b) Practical- BOT-G-DSE-B-6-4-P

SEME STER	CORE COURSES (CC-1-4)	ABILITY ENHANCEMENT COMPULSORY COURSE (AEC-1&2)	SKILL ENHANCEMEN T COURSE (SEC-1-4)	DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-1&2)
I	PLANT DIVERSITY I (PHYCOLOGY, MYCOLOGY, PHYTOPATHOLOGY, BRYOPHYTES AND ANATOMY) BOT-G-CC-1-1-TH	AECC-1 ENGLISH COMUUNICATIO N		
	PRACTICALS BOT-G-CC-1-1-P			
	OTHER DESCIPLINES (2)			
II	PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY, MORPHOLOGY AND TAXONOMY) BOT-G-CC-2-2-TH	AECC-2 ENVIRONMENTA L SCIENCE		
	PRACTICALS BOT-G-CC-2-2-P			
	OTHER DESCIPLINES (2)			
III	CELL BIOLOGY, GENETICS AND MICROBIOLOGY BOT-G-CC-3-3-TH		SEC-A	
	PRACTICALS BOT-G-CC-3-3-P			
	OTHER DESCIPLINES (2)			
IV	PLANT PHYSIOLOGY AND METABOLISM BOT-G-CC-4-4-TH		SEC-B	
	PRACTICALS BOT-G-CC-4-4-P			
	OTHER DESCIPLINES (2)			
V			SEC-A	DSE-A (any one from GROUP A) THEORY & PRACTICAL
				OTHER DESCIPLINES (2)
VI			SEC-B	DSE-B (any one from GROUP B) THEORY & PRACTICAL
				OTHER DESCIPLINES (2)

SEMESTER I

CORE COURSE 1

PLANT DIVERSITY I (PHYCOLOGY, MYCOLOGY, PHYTOPATHOLOGY, BRYOPHYTES AND ANATOMY) (BOT-G-CC-1-1-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Introduction to different plant groups

.....2 lectures

2. Phycology

2.1. Diagnostic characters and examples of Cyanophyceae, Rhodophyceae, Chlorophyceae, Charophyceae and Phaeophyceae, 2.2 Classification: Criteria and system of Fritsch, 2.3. Life histories of *Chlamydomonas*, *Chara* and *Ectocarpus*, 2.4. Role of algae in the environment, agriculture, biotechnology and industry.

.....14 lectures

3. Mycology

3.1 Diagnostic characters and examples of Oomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina (Ainsworth, 1973). 3.2 Life histories of *Rhizopus* and *Ascobolus*, 3.3. Economic importance of fungi, 3.4 Fungal symbioses: *Mycorrhiza*, Lichen and their importance.

.....12 lectures

4. Phytopathology

4.1 Symptoms - necrotic, hypoplastic and hyperplastic, 4.2 Koch's postulates, 4.3 Biotrophs and Necrotrophs, 4.4 Disease triangle, 4.5 Pathotoxins and phytoalexins (brief concept), 4.6 Symptoms, causal organism, disease cycle and control measures of plant diseases (Late blight of potato, Brown spot of Rice, Stem rot of jute).

.....10 lectures

5. Bryophytes

5.1 Unifying features of archaegoniates and transition to land habit, 5.2 Amphibian nature of bryophytes, 5.3 Diagnostic characters and examples of Hepaticopsida, Anthocerotopsida and Bryopsida (Proskauer 1957), 5.4 Life histories of *Marchantia* and *Funaria*, 5.5 Ecological and economic importance.

.....10 lectures

6. Anatomy

6.1 Stomata - Types (Metcalfe & Chalk), 6.2 Anatomy of root, stem and leaf of monocots and dicots, 6.3 Stellar types and evolution, 6.4 Secondary growth – normal in dicot stem and anomaly in stem of *Tecoma* & *Dracaena*.

.....12 lectures

**PRACTICAL- PLANT DIVERSITY I (PHYCOLOGY, MYCOLOGY, PHYTOPATHOLOGY, BRYOPHYTES
AND ANATOMY) (BOT-G-CC-1-1-P)
(Credits 2)**

1. **Work out:** Microscopic preparation, drawing and labeling of *Chlamydomonas*, *Chara*, *Ectocarpus*, *Rhizopus* and *Ascobolus*
2. **Anatomical studies (following double staining method) of:** 2a. Stem- *Cucurbita*, sunflower and maize. 2b. Root- *Colocassia*, gram and orchid. 2c. Leaf- Nerium
3. **Identification with reasons:** 3a. Cryptogamic specimens (macroscopic/microscopic as prescribed in the theoretical syllabus. 3b. Pathological specimens (herbarium sheets) of Late blight of potato, Brown spot of rice and stem rot of jute.
4. **Laboratory records:** Laboratory note books (regularly signed) and slides (prepared in class) are to be submitted at the time of Practical Examination. Regular attendance in the class must be credited.
5. At least one local excursion to be conducted to give an idea of plant diversity, habitat of algae and fungi

SEMESTER II

CORE COURSE 2

**PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY, MORPHOLOGY AND
TAXONOMY) (BOT-G-CC-2-2-TH)
THEORETICAL
(Credits 4, Lectures 60)**

1. Pteridophytes

1.1 Diagnostic characters and examples of Psilophyta, Lycophyta, Sphenophyta & Filicophyta (Gifford & Foster 1989). 1.2 Life histories of *Selaginella* and *Pteris*, 1.3 Economic importance.

.....12 lectures

2. Gymnosperms

2.1 Progymnosperms (brief idea), 2.2 Diagnostic characters and examples of Cycadophyta, Coniferophyta and Gnetophyta (Gifford & Foster 1989), 2.3 Life histories of *Cycas* and *Pinus*, 2.4 *Williamsonia* (reconstructed), 2.5 Economic importance of Gymnosperms.

.....12 lectures

3. Paleobotany & Palynology

3.1 Fossil, fossilization process and factors of fossilization, 3.2 Importance of fossil study. 3.3 Geological time scale, 3.4 Palynology - Definition, spore & pollen (brief idea), Applications.

.....10 lectures

4. Angiosperm Morphology

4.1 Inflorescence types with examples, 4.2 Flower, 4.3 Fruits and seeds- type and examples.

.....12 lectures

5. Taxonomy of Angiosperms

5.1 Artificial, Natural and Phylogenetic systems of classification with one example each, 5.2 Diagnostic features of following families- Malvaceae, Leguminosae (Fabaceae), Cucurbitaceae,

Rubiaceae, Compositae (Asteraceae), Solanaceae, Acanthaceae, Labiatae (Lamiaceae), Orchidaceae, Gramineae (Poaceae).

.....14 lectures

**PRACTICAL- PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY,
MORPHOLOGY AND TAXONOMY) (BOT-G-CC-2-2-P)
(Credits 2)**

1. Dissection, drawing and labelling, description of angiospermic plants and floral parts, floral formula and floral diagram, identification (family) from the following families: Leguminosae (Fabaceae), Malvaceae, Solanaceae, Labiatae (Lamiaceae), Acanthaceae.

2. Identification with reasons:

Macroscopic specimens of *Selaginella* and *Pteris*, male and female strobilus of *Cycas* and *Pinus*, Anatomical slides (stellar types, transfusion tissue, sieve tube, sunken stomata, lenticels), inflorescence types.

3. Spot identification of the following Angiospermic plants (scientific names and families): *Sida rhombifolia* (Malvaceae), *Abutilon indicum* (Malvaceae), *Cassia sophera* (Fabaceae), *Tephrosia halimtonii* (Fabaceae), *Crotolaria palida* (Fabaceae), *Coccinia grandis* (Cucurbitaceae), *Solanum indicum* (Solanaceae), *Nicotiana plumbagenifolia* (Solanaceae), *Leucas aspera* (Lamiaceae), *Leonurus sibiricus* (Lamiaceae), *Parthenium hysterophorus* (Asteraceae), *Tridax procumbense* (Asteraceae), *Eclipta prostrate* (Asteraceae), *Eragrostis tenella* (Poaceae), *Chrysopogon aciculatus* (Poaceae), *Eleusine indica* (Poaceae), *Vanda taesellata* (Orchidaceae).

4. Laboratory records: Laboratory note books (regularly signed) and slides (prepared in class) are to be submitted at the time of Practical Examination. Regular attendance in the class must be credited.

5. Field excursion: Local Excursions (at least two including one to Acharya Jagadish Chandra Bose Botanic Garden, Shibpur, Howrah)

6. Field Records: Field note book and 15 herbarium sheets of common Angiospermic weeds are to be prepared and submitted at the time of Practical Examination. Regular attendance in the class must be credited.

SEMESTER III

CORE COURSE 3

CELL BIOLOGY, GENETICS AND MICROBIOLOGY (BOT-G-CC-3-3-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Cell Biology and Genetics

1.1 Ultrastructure of nuclear envelope, nucleolus and their functions, 1.2 Molecular organisation of metaphase chromosome (Nucleosome concept).

-6 lectures
2. Chromosomal aberrations- 2.1 deletion, duplication, inversion & translocation, 2.2 Aneuploidy & Polyploidy-types, importance and role in evolution.
-6 lectures
3. Central Dogma, 3.1 Transcription and Translation.
-10 lectures
4. Genetic Code- properties.
-4 lectures
5. Linkage group and Genetic map (three-point test cross).
-6 lectures
6. Mutation – 6.1 Point mutation (tautomerisation; transition, transversion and frame shift), 6.2 Mutagen-physical and chemical.
-8 lectures
7. Brief concept of Split gene, Transposons.
-4 lectures

2. Microbes

- 2.1 Viruses- Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; 2.2 Bacteria- discovery, general characteristics and cell structure; reproduction- vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.
- 16 lectures

RACTICAL- CELL BIOLOGY, GENETICS AND MICROBIOLOGY (BOT-G-CC-3-3-P) (Credits 2)

1. Cell Biology:

Staining (Aceto-orcein) and squash preparation of onion root tip: study of mitotic stages. Determination of mitotic index (from onion root tip).

2. Microbiology:

Workout gram staining (curd/any natural source)

3. Identification with reasons:

Cytological slides of different mitotic and meiotic stages.

Different forms of bacteria (*Coccus*, *Bacillus*, *Spiral*)

4. Laboratory Records: Laboratory note books (regularly signed) and slides (prepared in class) are to be submitted at the time of Practical Examination. Regular attendance in the class must be credited

SEMESTER IV

CORE COURSE 4

PLANT PHYSIOLOGY AND METABOLISM (BOT-G-CC-4-4-TH) THEORETICAL (Credits 4, Lectures 60)

1. Proteins

1.1 Primary, secondary and tertiary structure, 1.2 Nucleic acid- DNA structure, RNA types, 1.3 Enzyme- Classifications with examples (IUBMB), Mechanism of action.

.....8 lectures

2. Transport in plants

2.1 Ascent of sap and Xylem cavitation , 2.2 Phloem transport and source-sink relation.

.....4 lectures

3. Transpiration

3.1 Mechanism of stomatal movement, significance.

.....4 lectures

4. Photosynthesis

4.1 Pigments, Action spectra and Enhancement effect, 4.2 Electron transport system and Photophosphorylation, 4.3 C3 and C4 photosynthesis, CAM- Reaction and Significance.

.....12 lectures

5. Respiration

5.1 Glycolysis & Krebs cycle— Reactions and Significance, 5.2 ETS and oxidative phosphorylation.

.....8 lectures

6. Nitrogen metabolism

6.1 Biological dinitrogen fixation, 6.2 Amino acid synthesis (reductive amination and transamination).

.....6 lectures

7. Plant Growth regulators

7.1 Physiological roles of Auxin, Gibberellin, Cytokinin, Ethylene, ABA.

.....10 lectures

8. Photoperiodism (Plant types, Role of phytochrome and GA in flowering) and Vernalization.

.....6 lectures

9. Senescence (brief idea).

.....2 lectures

PRACTICAL- PLANT PHYSIOLOGY AND METABOLISM (BOT-G-CC-4-4-P) (Credits 2)

Plant Physiology:

i) Experiment on Plasmolysis.

ii) Measurement of leaf area (graphical method) and determination of transpiration rate per unit

area by weighing method.

iii) Imbibition of water by dry seeds - proteinaceous and fatty seeds.

iv) Evolution of O₂ during photosynthesis (using graduated tube).

v) Evolution of CO₂ during aerobic respiration and measurement of volume.

SEC A

PLANT BREEDING AND BIOMETRY (BOT-G-SEC-A-3/5-1)

(Credits 2, Lectures 30)

1. Plant breeding:

1.1 Introduction and objective, 1.2 Techniques of hybridisation.

.....2 lectures

2. Mass and Pure line selection:

2.1 Procedure, 2.2 Advantages and limitations.

.....8 lectures

3. Heterosis and hybrid seed production.

.....4 lectures

4. Role of mutation, polyploidy, distant hybridization and role of biotechnology in crop improvement.

.....8 lectures

5. Biometry:

5.1 Measures of central tendency (Mean, Median and Mode), 5.2 Standard error and standard deviation, 5.3 Test of significance: Chi-square test for goodness of fit.

.....8 lectures

BIOFERTILIZERS (BOT-G-SEC-A-3/5-2)

(Credits 2, Lectures 30)

1. **Biofertilizers:** General account about microbes used as biofertilisers; *Rhizobium*-identification, mass multiplication. Actinorrhizal symbiosis.

.....4 lectures

2. ***Azospirillum***- identification, mass multiplication, associative effect of different microorganisms. *Azotobacter* and crop response to *Azotobacter* inoculums.

.....6 lectures

3. Cyanobacteria, *Azolla*, *Anabaena* and *Azolla* association, blue green algae and *Azolla* in rice cultivation.

.....6 lectures

4. **Mycorrhizal association:** 4.1 Types of Mycorrhizal association- Brief idea, 4.2 Its influence on growth and yield of crop plants.

-6 lectures
5. **Organic farming:** 5.1 Green manuring and organic fertilizers, 5.2 Biocompost and vermicompost- making methods and field applications. 5.3 Recycling of biodegradable municipal, industrial and agricultural wastes.

.....8 lectures

SEC B
PLANT BIOTECHNOLOGY (BOT-G-SEC-B-4/6-3)
(Credits 2, Lectures 30)

1. **Plant tissue culture-** 1.1 Introduction and basic concepts, 1.2 Cellular potency, 1.3 Callus culture and plant regeneration.

.....4 lectures

2. **Micropropagation-** 2.1 Somatic embryogenesis and artificial seed.

.....4 lectures

3. Protoplast culture and its application.

.....6 lectures

4. **Recombinant DNA technology-** 4.1 Recombinant DNA, 4.2 Restriction enzymes, 4.3 Plasmids as vectors.

.....8 lectures

5. Gene cloning (basic steps).

.....4 lectures

6. **Achievements in crop biotechnology-** 6.1 Pest resistant plant (Bt cotton), 6.2 Transgenic crops with improved quality (flavr tomato and golden rice).

.....4 lectures

MUSHROOM CULTURE TECHNOLOGY (BOT-G-SEC-D-4/6-4)
(Credits 2, Lectures 30)

1. **Mushroom-** nutritional and medicinal value of mushrooms. Poisonous mushrooms.

.....4 lectures

2. Cultivation techniques/ technology of edible mushrooms in India: *Volvarealla volvacea*, *Pleuretus citrinopyrineatus*, *Agaricus bisporus*.

.....12 lectures

3. **Storage-** short term and long term, storage, drying.

.....6 lectures

4. **Food preparation-** types of foods prepared from mushroom. Cost and benefit ratio.

.....6 lectures

5. **Research centres-** national and regional.

.....2 lectures

DSE A (Group A)
PHYTOCHEMISTRY AND MEDICINAL BOTANY (BOT-G-DSE-A-5-1-TH)
THEORETICAL
(Credit 4, Lectures 60)

1. **Medicinal botany-** History, scope and importance of medicinal plants, a brief idea about indigenous medicinal sciences- Ayurveda, Siddha and Unani. Polyherbal formulations.
.....14 lectures
2. **Pharmacognosy-** 2.1 Scope and its importance, 2.2 Primary metabolites, 2.3 Secondary metabolites- alkaloids, terpenoids, phenolics and their functions.
.....10 lectures
3. **Organoleptic** evaluation of crude drugs.
.....10 lectures
4. **Pharmacologically active constituents:** Source plants (one example), parts used and uses of: 4.1 Steroids (Diosgenin, Digitoxin), 4.2 Tannin (Catechin), 4.3 Resins (Gingerol, Curcuminoids), 4.4 Alkaloids (Strychnine, Reserpine, Vinblastine), 4.5 Phenols (Capsaicin).
.....6 lectures
5. **Ethnobotany and folk medicine:** 5.1 Brief idea, 5.2 Applications of ethnobotany, 5.3 Application of natural product to certain diseases- Jaundice, Cardiac and Diabetics.
.....20 lectures

PRACTICAL- PHYTOCHEMISTRY AND MEDICINAL BOTANY (BOT-G-DSE-A-5-1-P)
(Credit 2)

1. Preparations of solution and buffers
2. Acquaintance with laboratory instruments- Autoclave, Incubator, Clinical centrifuge, Analytical balance, pH meter, Colorimeter, Water bath, Distillation plant, Laminar air flow.
3. Qualitative test for proteins and carbohydrates, reducing and non reducing sugar (glucose, fructose and sucrose)
4. Tests (chemical) for tannin and alkaloid
5. Identification of medicinal plants (list to be provided)
6. Field study (local) and listing of medicinal plants. Records to be substantiated with photographs and description.

NATURAL RESOURCE MANagements (BOT-G-DSE-A-5-2-TH)

THEORETICAL

(Credits 4, Lectures 60)

1. Natural resources- definition and types.
.....2 lectures
2. Sustainable utilization- concept, approaches (economic, ecological and socio-cultural).
.....10 lectures
3. Land utilization. Soil degradation and management.
.....8 lectures
4. Water, fresh water marine, estuarine. Wetlands- threats and management.
.....10 lectures
5. Biological resources, biodiversity- definition and types. Significance, threats and management strategies.
.....10 lectures
6. Forests- definition, cover and its significance (with special reference to India). Major and minor forest products.
.....8 lectures
7. Energy- renewable and non-renewable source of energy.
.....8 lectures
8. EIA and waste management.
.....4 lectures

PRACTICAL- NATURAL RESOURCE MANagements (BOT-G-DSE-A-5-2-P)

(Credits 2)

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Measurement of dominant woody species by DBH (diameter at breast height)
3. Study of community structure by Quadrat method and determination of minimal size of quadrat, frequency density and abundance of components to be done during field visit.
4. Measurement of dissolved O₂ by azide modification of Winkler's method.
5. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)

DSE B
ECONOMIC BOTANY (BOT-G-DSE-B-6-3-TH)
THEORETICAL (Credits 4, Lectures 60)

1. Origin of cultivated plants: 1.1 Concepts of centres of origin and their importance with reference to Vavilov's work.
.....12 lectures
2. Rice- origin, morphology and uses.
.....12 lectures
3. Legumes: General account with special reference to *Vigna*.
.....8 lectures
4. Beverages: Tea- morphology, processing and uses.
.....12 lectures
5. Study of the following economically important plants (Scientific names, families, parts used and importance): 5.1 Cereals- Rice, wheat, 5.2 Pulses- Mong, gram, 5.3 Spices- Ginger, cumin, 5.4 Beverages- Tea, coffee, 5.5 Medicinal plants- Cinchona, neem, Ipecac, Vasaka, 5.6 Oil yielding plants- Mustard, groundnut, coconut, 5.7 Vegetables- Potato, raddish, bottle gourd, cabbage, 5.8 Fibre yielding plants- Cotton, jute, 5.9 Timber yielding plants- Teak, Sal 5.10 Fruits- Mango, apple, 5.11 Sugar yielding plant- Sugarcane.
.....16 lectures

PRACTICAL- ECONOMIC BOTANY (BOT-G-DSE-B-6-3-P)
(Credits 2)

1. Study of economically important plants (rice/jute/ tea) through herbarium specimens and field study.
2. Study of cultivation practices in field and submission of report.
3. Study of local economically important plants and submission of report with photographs.

HORTICULTURAL PRACTICES AND POST HARVEST
TECHNOLOGY (BOT-G-DSE-B-6-4-TH)
THEORETICAL
(Credits 4, Lectures 60)

1. Horticulture- role in rural economy and employment generation. Urban horticulture- its scope and importance.
.....6 lectures
2. Ornamental plants- identification and salient features of some ornamental plants (rose, marigold, gladiolus, gerberas, tube rose, carnations, cacti and succulents). Ornamental flowering trees (Gulmohor, Lagerstromia, Shimul, Coral tree and jacaranda).

.....12 lectures

3. Identification of some fruits and vegetable plants- Citrus, Banana, Papaya, Mango, Jackfruit, Chillies and cucurbits. Fruit processing- scope and benefits.

.....10 lectures

4. Horticultural techniques- propagation methods, application of manure, fertilizers, nutrients and PGR. Weed control. Biofertilizers and biopesticides.

.....12 lectures

5. Post harvest technology- importance of post harvest technology in horticultural practices. Harvesting and handling of fruits, vegetables and cut flower. Methods of preservation and processing.

.....10 lectures

6. Disease control and management- field and post harvest diseases of common crops. Crop sanitation, quarantine practices. Identification of common diseases and pest of fruits and vegetable crops.

.....10 lectures

PRACTICAL- HORTICULTURAL PRACTICES AND POST HARVEST TECHNOLOGY (BOT-G-DSE-B-6-4-P)

(Credits 2)

1. Field trips to gardens, standing crop sites, nurseries, vegetable gardens, horticultural fields and cold storages.

REFERENCES

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. Frenchel, 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. 22
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

3. Microbiology

1. Stainer, T.Y., Ingrahm, J.L., Wheelis, M.L. & Painter, P.R. General Microbiology (5th ed.), 1986, Macmillan Education 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. Jay, J.M. Modern Food Microbiology (5th ed.), 1996, Chapman & Hall
5. Madigan, M.T., Marinko, J.M. & Parker, J. Brock, Biology of Microorganisms (10th ed.), 2003, Prentice Hall
10. Hull, R. Matthew Plant Virology (4th ed.), 2002, Academic Press
6. Biswas, S.B. & Biswas, A. An Introduction to Viruses (4th ed.), 1996, Vikas Publishing House
7. Agarwal, A.K. & Parihar, P. Industrial Microbiology, 2005, Agrobios (India)

8. Power, C.B. & Dagimawata, H.F. General Microbiology, Vol. I&II, Himalaya Publishing House
9. Mitchel, R. Environmental Microbiology, Latest Ed. Wiley, N.Y.
10. Sale, A.J. Fundamental Principles of Microbiology, Latest Ed., Tata McGraw Hill
11. Banerjee, A.K. & Banerjee, N. Microbiology & Immunology, 2006, new Central Book Agency
12. 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 23
2. Arora, D. (ed.). Hand book of Fungal Biotechnology (2nd ed.), 2003, Dekker, N.Y.
3. Sharma, P.D. Fungi & Allied Organisms, 2005, Narosa Publishing House
4. Deacon, J.W. Fungal Biology, 2006, Black Well Science Ltd.
5. Ingold, C.T. & Hudson, H.J. The Biology of Fungi 96th ed.), 1993, Chapman & Hall
6. Sharma, O.P. Text book of Fungi, Tata McGraw Hill
7. Vashista, B.R. Fungi, Latest Ed., S. Chand & Company
8. Chopra, G.L. and Verma, V.A. Text Book of Fungi, Pradeep Publications
9. Mehrotra, R.S. and Aneja, K.R. An Introduction to Mycology, Wiley Eastern Ltd.
10. Sharma, P.D. the Fungi, Rastogi Publication
11. Mehrotra, R.S. & Agarwal, A. plant Pathology (2nd ed.), 2003, Tata McGraw Hill
12. Singh, R.S. Principles of Plant Pathology (4th ed.), 2002, oxford & IBH Publishing Com.
13. Manners, J.G. Principles of Plant Pathology (2nd ed.), 1993, Cambridge University Press
14. Singh, R.S. Plant diseases, Oxford & IBH Publishing Com
15. Rangaswami, G.K. & Mahadevan, A. Diseases of Crop Plants in India, Prentice Hall
16. Sharma, P.D. Plant Pathology (2nd ed.), Rastogi Publications
17. Strange, R.N. (ed.) Introduction of plant Pathology, 2003, Wiley
18. 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

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. Nair, P.K. Pollen Morphology of Angiosperms, Latest Ed., Scholar Publications
5. Shivanne, K.H. Pollen Biology & Biotechnology, 2003, Oxford & IBH
6. 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. Bhojwani, S.S. & Bhatnagar, S.D. The Embryology of Angiosperms (4th ed.), 1989, Publishing House.

8. Pteridophytes

1. Spore, K.R. The Morphology of Pteridophyte, Latest Ed. , Huchinson & 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.

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.

10. Ecology & Plant Geography

1. Shukla, R.S. & Chandel, P.S. Plant Ecology, Latest Ed., S. Chandel and Co.
2. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House
3. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company
4. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders
5. Sharma, P.D. Elements of Ecology, Latest Ed., Rastogi Publications
6. Ambasht, R.S. & Ambasht, N.K. A Text Book of Plant Ecology, Latest Ed., CBS Publication & Distributors
7. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.

8. Krishnamurthy, K.V. An Advanced Text Book on Biodiversity, 2003, Oxford & IBH Publishing Co. Ltd.
9. Mitra, D., Guha, J.K., Chowdhury, S.K. Studies in Botany, Vol. II (7th ed.) Moulik Library.
10. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates

11. Evolution

1. Futuyma., D. Evolution. 2015. (3rd Ed.) Sinauer Associates

12. Anatomy

1. Fahn, A. Plant Anatomy (4th ed.), 1990, Wiley Eastern.
2. Eames, A.J. & Mac. Daniels, L.H. An Introduction to Plant Anatomy, Latest Ed., McGraw Hill
3. Esau, K. Anatomy of Seed Plants (2nd ed.), 1977, John Wiley & Sons
4. Pandey, B.P. Plant Anatomy, Latest Ed., S. Chand & Company
5. Tayal, M.S. Plant Anatomy, Latest Ed., Rastogi Publications
6. Roy, P. Plant Anatomy, Latest Ed., New Central Book Agency
7. Morphology and Taxonomy of Angiosperms
8. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press
9. Sambamurthy, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
10. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH
11. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House
12. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill
13. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers
14. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press
15. Dutta, S.C. systematic Botany, Latest Ed., Wiley Eastern.
16. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.
17. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.
18. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.
19. Radford. A.B. Fundamentals of Plant Systematics, Latest Ed., Harper & Row.
20. 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.
21. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.
22. Subramanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.
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, Wadsworth 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. Chaudhuri, D., Kar, D.K., and Halder, S.A. Handbook of Plant Biosynthetic Pthways 2008, New Central Book Agencies.
15. Mehta, S.L., Lodha, M.L. & Bane, P.V. Recent Advances in Plant Biochemistry, 1989. I.C.A.R.
16. Conn, E.E. and Stumpf, R.R. Outlines of Bio-Chemistry, Latest Ed., Wiley Eastern.
17. Singhal, G.S. Concepts of Photobiology: Photosynthesis & Photomorphogenesis, 1999. Narosa Publishing House.
18. Hall. D.O. & Rao, K.K. photosynthesis (5th ed.), 1995, Cambridge University Press.
19. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.

15. Pharmacognosy/ Medocinal Botany

1. Trease & Evans. Pharmacognosy, Saunders.
2. Trivedi P.C. 2006. Medicinal Plants: Ethnobotanical approach, Agrobios India
3. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur 1995.

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. Jain, H.K. Genetics, 1999, Oxford & IBH Publishing Company.
26. Swanson, C.P., Merz, T. & Young, W.J. Cytogenetics, 1981, Prentice Hall.
27. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. & Walter, P. Molecular Biology of the Cell, 2002 (4th ed.), Garland Sciences.
28. Gardner, E.J., Simmons, M.J. & Snustad, D.P. Principles of Genetics (8th ed.) 1991, John Wiley & Sons.
29. Kar, D.K. and Halder, S. Cell Biology, Genetics and Molecular Biology 2008, New Central Book Agency.
30. Roy, S.C. and De, K.K. Cell Biology, 1997, New Central Book Agency.
31. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell. 2015. 6th Ed: Garland Science.

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. Singh, B.D. Plant Breeding, Principles & Methods (7th ed.), 2005, Kalyani Publishers.
4. Roy, D. Plant Breeding: Analysis & Exploitation of Variation, 2000, Narosa Publishing House.
5. Kar, D.K. and Halder, S. Plant Breeding & Biometry, 2006, New Central Book Agency.
6. 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. Walker, J.M. & Rapley, R. Molecular Biology & Biotechnology, 2000, Royal Society of Chemistry Publishing House
3. Dubey, R.C. Biotechnology, Latest Ed., S.Chand & Company Pvt. Ltd.
4. Bhojwani, S.S. & Razdan, M.I. Plant Tissue Culture: Theory and Practise, Elsevier
5. Rajdan, M.K. An Introduction to Plant Tissue Culture, Latest Ed., Oxford & IBH
6. Jha, T.B. & Ghosh, B. Plant Tissue Culture, 2003, Universities Press
7. Singh, B.D. Biotechnology Latest ed., Kalyani Publishers.
8. Kar, D.K. & Halder, S. Plant Breeding, Biometry & Biotechnology, 2010, New Central Book Agency
9. Gupta, P.K. Biotechnology & Genomes, latest Ed., Rastogi Publications
10. Slatter, A., Scott, N. & Fowler, N. Plant Biotechnology, 2003, Oxford University Press
11. Dey, K.K. Plant Tissue Culture, 1992, New Central Book Agency

19. Resource methodology

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

20. Biofertilizers

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas, S.C., Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming, Akta Prakashan, Nadiad.

21. Mushroom culture technology

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.