UNIVERSITY OF GOUR BANGA

(Established under West Bengal Act XXVI of 2007)
N.H.-34 (Near Rabindra Bhawan), P.O.: Mokdumpur,
Dist.: Malda, West Bengal, Pin-732 103

CHOICE BASED CREDIT SYSTEM
B.Sc. BOTANY
HONOURS

DRAFT

(w.e.f. June 2019)

Scheme for CBCS in B.Sc. Honours Program- Botany							
ACADEMIC SEMESTERS	**DISCIPLINE CORE (DC) (4+2=6)**	**DISCIPLINR SPECIFIC ELECTIVE (DSE) (4+2=6)**	**GENERIC ELECTIVE (GE) (4+2=6)**	**ABILITY ENHANCEMENT COMPULSORY (AEC) (2)**	**SKILL ENHANCEMENT COURSE (SEC) (2)**	**CREDITS**	**MARKS**
SEM-I	**DC 1: Algae and Microbiology**	-	**GE-1**	**ENVS**		**20**	**200**
	DC 2: Fungi, Lichens and Plant Pathology	-					
SEM-II	**DC 3: Archegoniate and Paleobotany**	-	**GE-2**	**Communicative English/ Bengali MIL**		**20**	**200**
	DC 4 : Morphology and Anatomy of Angiosperms	-					
SEM-III	**DC 5: Plant Systematics**	-	**GE-3**			**24**	**200**
	DC 6 : Plant Ecology and Phytogeography and Biodiversity	-					
	DC 7. Economic botany	-					
SEM-IV	**DC 8: Cell biology and Plant Breeding**	-	**GE-4**			**24**	**200**
	DC 9 : Genetics and Biostatistics	-					
	DC 10: Reproductive Biology of Angiosperms	-					
SEM-V	**DC 11. Plant Physiology**	**DSE-1**	-		**SEC-1**	**26**	**250**
	DC 12: Plant Metabolism	**DSE-2**	-				
SEM-VI	**DC 13: Biomolecules**	**DSE-3**	-		**SEC-2**	**26**	**250**
	DC 14. Plant Biotechnology	**DSE-4/DP Dissertation/Project Work**	-				
TOTAL						**140**	**1300**

- **Students pursuing DC in Botany will have to opt for SEC and DSE in Botany only**
- **GE subject must be different from DSC in Botany (Chemistry/Zoology)**

Marks and Question type distribution for Botany (Honours) course of studies								
No. of Courses	Total Credit	Total Marks	Full Marks of Each Course	Internal Assessment (IA)		End Semester Examination (ESE)		
				Attendance (4%)	Cont. Evaluation (6%)	Theoretical		Practical
						Descriptive	MCQ	
DC 14 courses	14x6=84	14x50=700	50	4+6=10		25	nil	15
DSE 04 Courses	4x6=24	4x50=200	50	4+6=10		25	nil	15
GE 04 Courses	4x6=24	4x50=200	50	4+6=10		25	nil	15
SE 02 Courses	2x2=4	2x50=100	50	4+6=10		40	nil	nil
AEC-1 (ENVS)	1x2=2	1x50=50	50	10 project		nil	40	nil
AEC-2 Communicative Bengali/English	1x2=2	1x50=50	50	4+6=10		nil	40	nil
Grand Total	140	1300	-	-		-	-	-

- **DISCIPLINE CORE (DC)**
- **DISCIPLINR SPECIFIC ELECTIVE (DSE)**
- **GENERIC ELECTIVE (GE)**
- **SKILL ENHANCEMENT COURSE (SEC)**
- **ABILITY ENHANCEMENT COMPULSORY (AEC)**

DETAILED COURSE STRUCTURE

DISCIPLINE CORE (DC)

YEAR 1

SEMESTER I

DC 1: Algae and Microbiology (Theory) (Total Lectures 60)

DC2: Fungi, Lichens and Plant Pathology (Theory) (Total Lectures 60)

SEMESTER II

DC 3: Archegoniate (Bryology, Pteridology, Gymnology) and Paleobotany (Total Lectures 60)

DC 4: Morphology and Anatomy of Angiosperms (Theory) (Total Lecture 60)

YEAR 2

SEMESTER III

DC 5: Plant Systematics (Theory) (Total Lecture 60)

DC 6: Plant Ecology and Phytogeography and Biodiversity (Theory) (Total Lecture 60)

DC 7. Economic botany (Theory) (Total Lecture 60)

SEMESTER IV

DC 8: Cell biology and Plant Breeding (Theory) (60Lectures)

DC 9: Genetics and Biostatistics (Theory) (60 Lectures)

DC 10: Reproductive Biology of Angiosperms (Theory) (60 Lectures)

YEAR 3

SEMESTER V

DC 11: Plant Physiology (Theory) (60 Lectures)

DC 12: Plant Metabolism (Theory) (60 Lectures)

SEMESTER VI

DC 13: Biomolecules (Biochemistry) (Theory) (Total Lectures 60)

DC 14. Plant Biotechnology (Theory) (60 Lectures)

DISCIPLINE SPECIFIC ELECTIVE (DSE)

YEAR 3: SEMESTER V: DSE-1 and DSE-2 , SEMESTER VI: DSE-3 and DSE-4 (Project)

(Any three from the following; One each for each DSE course)

1. **Analytical Techniques in Plant Sciences**
2. **Bioinformatics**
3. **Stress Biology**
4. **Plant Breeding**
5. **Natural Resource Management**
6. **Industrial and Environmental Microbiology**

GENERIC ELECTIVES (GE)

YEAR 1: SEMESTER I: GE-1; SEMESTER II: GE-2
YEAR 2: SEMESTER III: GE- 3; SEMESTER IV: GE-4

(Any four from the following; One each for each GE course)

1. **Biodiversity (Microbes, Algae, Fungi and Archegoniate)**
2. **Plant Ecology and Taxonomy**
3. **Plant Anatomy and Embryology**
4. **Plant Physiology and Metabolism**
5. **Economic Botany and Biotechnology**
6. **Environmental Biotechnology**

SKILL ENHANCEMENT COURSES (SEC)

YEAR 3: SEMESTER V: SE- 1, SEMESTER VI: SE-2

(Any two from the following; One each for each SE course)

1. Floriculture
2. Mushroom Culture Technology
3. Biofertilizers
4. Ethnobotany
5. Plant Diversity and Human Welfare
6. Medicinal Botany
7. Herbal Technology

DISCIPLINE CORE (DC)

Algae and Microbiology
Fungi, Lichens and Plant Pathology
Archegoniate and Paleobotany
Morphology and Anatomy of Angiosperms
Plant Systematics
Plant Ecology and Phytogeography and Biodiversity
Economic botany
Cell biology and Plant Breeding
Genetics and Biostatistics
Reproductive Biology of Angiosperms
Plant Physiology
Plant Metabolism
Biomolecules
Plant Biotechnology

Discipline Core (DC)

YEAR 1: SEMESTER I

(Credits: Theory-4, Practical-2)

DC 1: PAPER-1: Algae and Microbiology

(Theory) (Total Lectures 60)

Algae

1. General characteristics; Ecology and distribution; range of thallus organization; Cell structure
2. and components; cell wall, pigment system, reserve food (of only groups represented in the
3. syllabus), flagella; methods of reproduction;
4. Classification; criteria, system of Fritsch, and evolutionary classification of Lee (only upto groups);
5. Cyanophyta and Xanthophyta: Characteristic features, Morphology and life-cycle of *Anabaena* (Asexual cycle) and *Vaucheria,* Ultra Structure of cell; Heterocyst and role in N2 fixation.
6. Chlorophyta and Charophyta: Characteristic features, Morphology and life-cycle of *Chlamydomonas, Volvox, Oedogonium and Chara.*
7. Phaeophyta and Rhodophyta: Characteristic features, Morphology and life-cycle of*Ectocarpus* and *Polysiphonia.*
8. Diatom: Cell structure, Cell division, Auxospore formation in Centrales and Pennales.
9. Role of algae in the environment, agriculture, biotechnology and industry.: Biotechnology potential of microalgae for SCP; Production of Agar-agar; Algae as bio-fertilizer; Mass cultivation of algae for bio-diseal production.

Microbiology

1. Introduction to microbial world: Discovery, general characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure: Flagella (ultrastructure) & Pilli; Cell wall – chemical structure and differences between Gram +ve & Gram – ve bacteria; Bacterial genome and plasmid; Endospore - formation, structure and function.
2. Bacterial reproduction: Vegetative and asexual; Genetic Recombination (a) Transformation – with special emphasis on Natural and Induced competence and DNA uptake, (b) Conjugation ─ F- factor, F+ x F−, Hfr x F−, concept of F', chromosome mobilization, (c) Transduction–Generalised and specialized.
3. Economic importance of bacteria: Industrial Production of Vinegar and Streptomycin (brief outline); Enzyme (Amylase, Protease); Plant Growth Promoting Rhizobacteria (PGPR): Biological nitrogen fixation and nodulation process in legumes. Role of PGPR in agriculture as Biofertilizer and Biopesticides. Concept of Bioplastics.
4. **Viruses:** Discovery, physiochemical and biological characteristics; classification (Baltimore), general, structure with special reference to viroids and prions; replication (general account),
5. DNA virus, (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases

DC-1: PAPER 2 (Practical)

Algae

1. Work out of algal specimens through preparation of semi-permanent slides (stained with cotton blue) and drawing of reproductive structures with proper magnification using camera lucida drawing prism.: *Anabaena, Vaucheria, Volvox, Oedogonium, Chara, Ectocarpus and Polysiphonia*.

Microbiology

1. Types of Bacteria to be observed from permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation.
2. Gram Staining (Gram +Ve and Gram -Ve), Observation of Bacteriods in root Nodule (Simple staining: Methylene blue); Endospore staining with malachite green. (*Bacillus* spp.)
3. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.

Suggested Readings

1. Bold, H.C. & Wynne, M.J. .....Introduction to Algae: Structure & Reproduction [Prentice Hall]
2. Ganguly, H.C. &Kar, A.K.....College Botany Vol.-II [New Central Book Agency]
3. Hoek, C., Mann, D.G. &Jahns, H.M. 1995 .....Algae: an….. [Cambridge Univ. Press]
4. Kumar, H.D. & Singh, H.N. ....Introductory Phycology [East-West Press Pvt. Ltd]
5. Lee, R.E. .....Phycology [Cambridge Univ. Press]
6. Vashistha, B.R., Singh, A.K. & Singh, V.P.....Algae [S. Chand & Co. Pvt. Ltd.]
7. Atlas, R.M. .....Principles of Microbiology [McGraw Hill]
8. Banerjee, A.K. & Banerjee, N. ...Fundamentals of Microbiology and Immunology [New Central Book Agency]
9. Pelczar, M.J., Chan, P.C.S. & Krieg, N.R. .....Microbiology [Tata McGraw Hill]
10. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. & Painter, P.R. .....General Microbiology [Macmillan Education Ltd.]
11. Tortora, G.J., Funke, B.R. & Case, C.L. .....Microbiology - An Introduction [Dorling Kindersley India Pvt. Ltd. for Pearson Education]
12. Willey, M.J., Sherwood, L.M. & Woolverton, C.J.....Prescott, Harley and Klein's Microbiology [McGraw Hill]

DC2: PAPER 3: Fungi, Lichens and Plant Pathology
(Theory) (Total Lectures 60)

Fungi and Lichens

1. Introduction to true fungi; General characteristics; Thallus organization; Cell wall composition;; Teleomorphic and Anamorphic; Degeneration of sex in fungi; Parasexuality; Nutrition; Life Cycle Patterns.
2. Classification (Ainsworth 1973) up to sub-division diagnostic characters and examples.
3. Characteristic features; Ecology and significance; Thallus organisation; Reproduction; Life cycle with reference to *Rhizopus, Ascobolus, Agaricus* and *Penicillium.*
4. Symbiotic associations: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction and ecological role in pollution monitoring; Mycorrhiza- Ectomycorrhiza, Endomycorrhiza, Phosphate mobilization by AMF. Significance and role in Agriculture.
5. Applied Mycology: Role of fungi in biotechnology; Application of fungi in food industry. Fungi as Biocontrol agents; Mycotoxins.
6. Industrial production of Cheese, Ethanol, Baker's yeast, Amylase and Rivoflavin.

Plant Pathology

1. Introduction to plant pathology; Plant pathology in India and Global prospective; Concept of Disease in Plants and Types of Diseases.
2. Terms and definitions: Disease concept, Symptoms, Etiology, Inoculum and Infection, Pathogenesis, SAR and ISR, Disease triangle and disease cycle, Epidemic and Endemic, Sporadic and Pandemic Disease. Koch's postulate.
3. Mechanism of infection (Pre-penetration, Penetration and Post-Penetration), Plant defense responses with reference to Phytoalexins and PR proteins. Signal transduction leading to SAR and ISR.
4. Concept of plant disease management: IPM, Chemical, Biological and Quarantine. Concept of crop rotation.
5. Symptoms, Causal organism, Disease cycle and control measures of: Bacterial diseases – Citrus canker, Viral diseases – Tobacco Mosaic Disease. Fungal diseases – Late blight of potato and Black stem rust of wheat.
6. Worldwide development of plant pathology as a profession: Indian and International institutions of crop protection, Plant disease clinics.

DC2: PAPER 4 (Practical)

Fungi and Lichens

1. Study of asexual stage from temporary mounts, drawing and microscopic measurement: *Rhizopus, Ascobolous / Peziza* and *Agaricus.*
2. Study from permanent slides: Sexual stage in *Rhizopus*, Conidia of *Penicillium*, *Aspergillus* spp.
3. Isolation of AMF from soil through wet sieving and decanting method and comment on the type and nature of spore. (Demonstration)
4. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates through museum specimen.

Plant Pathology

1. Study from temporary mounts (Histopathology): Late Blight of Potato, Stem rot of Jute, Loose smut of wheat, Leaf rust of *Justicia*.
2. Study from permanent slides: Uredial, Telial, Pycnidial and Aecial stages of *Puccinia graminis,*
3. Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: TMV, Fungal diseases: Late and Early blight of Potato, Black stem rust of Wheat, Stem rot of Jute, Red rot of Sugarcane, leaf rust of *Justicia*, Tikka disease of Groundnut and White rust of Crucifers.

Suggested Readings

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
2. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
4. Kershaw, K.A. (1985), Physiological ecology of lichens, Cambridge University Press, Cambridge.
5. Negi, H.R.; Kareem, A., Lichens: The Unsung Heroes.
6. Negi, Hans Raj, Lichens: A valuable bioresource for environmental monitoring and sustainable development, Resonance. India, 2003,8(1), 51-58
7. Seaward, M.R.D. (1977) (Ed.), Lichen ecology, Academic Press, London.
8. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
9. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
10. Melhotra R.S and Aggarwal- II Ed. Plant Pathology, Mc.Graw Hill Education.

Discipline Core (DC)

YEAR 1 SEMESTER II

(Credits: Theory-4, Practical-2)

DC 3: PAPER 5: Archegoniate and Paleobotany

(Theory) (Total Lectures 60)

1. Introduction: Unifying features of archegoniates; Transition to land habit; Alternation of generations.
2. **Bryophytes:** General characteristics; Adaptations to land habit; Classification (Proskauer, 1957) up to class. Range of thallus organization. Ecological and economic importance of bryophytes with special reference to *Sphagnum*.
3. Type Studies- Bryophytes: Morphology, anatomy and reproduction and sporophyte development and alternation of generation of *Marchantia, Anthoceros, Sphagnum and Funaria.*
4. **Pteridophytes:** General characteristics; Classification up to class (Sporne, 1975); Concept of heterospory and origin of seed habit; Apogamy, and apospory; Stelar evolution. Ecological and economic importance of pteridophytes. Early land plants *Rhynia* and *Lepidodendron* (Reconstructed).
5. Type Studies- Pteridophytes: Morphology, anatomy and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included).
6. **Gymnosperms:** General characteristics, classification up to order (Stewart and Rothwell, 1993), Ecological and economic importance.
7. Vegetative morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included)
8. **Paleobotany:** Fossil: types and modes of preservation (Schopf, 1975), conditions of preservations, fossilization process;Geological time scale and major events of plant life through geological ages.: Indian Gondwana system with major megafossil assemblages; Importance of study of fossil.

DC 3: PAPER 6 (Practical)

1. Bryophytes

i. Morphology of thallus and permanent slide preparations of the following
ii. *Marchantia:* Whole mount of rhizoids& scales, vertical section Gemma cup, Antheridiophore, Archegoniophore
iii. *Anthoceros*- Dissection of sporophyte (to show stomata, spores, pseudoelaters, columella).
iv. *Funaria*- Whole mount of leaf, rhizoids, operculum, peristome, annulus, spores and longitudinal section of capsule.

2. Pteridophytes

i. Morphology and permanent slide preparations of the following
ii. *Selaginella* and *Lycopodium* : Transverse section of stem, whole mount of strobilus, longitudinal section of strobilus.
iii. *Equisetum*- Transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore.
iv. *Pteris*- Transverse section of sporophyll, whole mount of sporangium, mount of spores.

3. Gymnosperms

i. *Cycas*- Morphology (bulbil, leaf), whole mount of microsporophyll Microsporophyll, whole mount of spores (temporary slides).
ii. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male cones), transverse section of Needle, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides).

iii. Morphological studies of reproductive structures of *Pinus* (male and female cones), *Cycas* (Megasporophyll and Microsporophyll) *Gnetum* (male and female cones); , Transverse section of coralloid root, leaflet anatomy, (permanent slide).

4. **Paleobotany:**

i. Morphological study: *Ptilophyllum, Vertebraria,* and *Glossopteris* leaf fossils

ii. Study from permanent slides: T.S. of stem of *Rhynia, Lepidodendron, Calamites, Lyginopteris, Cordaites, and Medullosa.*

5. Botanical excursion: Enlistment of plants observed in the field and submission of field note book with 10-25 photographs.

Suggested Readings

1. Smith, G.M. .....Cryptogamic Botany Vol. 1 [McGraw Hill]
2. Puri, P. .....Bryophyte [Atmaram& Sons]
3. Rashid, A. .....An Introduction to Bryophyta [Vikas Publishing House]
4. Vashishta, B.R. .....Bryophyta [S. Chand & Co.]
5. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
6. Gifford, E.M. & Foster, A.S. .....Morphology and Evolution of Vascular Plants [Freeman & Co.]
7. Mukherjee, R.N. & Chakraborty, K. .....An Introduction to Vascular Cryptogams (Pteridophytes) [Kalyani Publishers]
8. Rashid, A. .....An Introduction to Pteridophyta [Vikas Publishing House]
9. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
10. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
11. Vasishta, P.C. .....Gymnosperms [S. Chand & Co.]
12. Bhatnagar, S.P. &Moitra, A. .....Gymnosperms [New Age International]
13. Arnold, C.R. .....An Introduction to Paleobotany [Agrobios India]
14. Andrews, Jr. H.N. .....Studies in Paleobotany [John Wiley & Sons Inc.]
15. Agashe, S.N. .....Palaeobotany [Oxford & IBH]
16. Taylor, T.N. .....Paleobotany-An introduction to fossil plant biology [McGraw Hill]
17. Meyen, S.V. .....Fundamentals of Paleobotany [Chapman & Hall]

DC 4 : PAPER 7: Morphology and Anatomy of Angiosperms

(Theory) (Total Lecture 60)

1. Introduction to angiospermic morphology, Palynology and Anatomy, scope and applications in systematics, forensic and pharmacognosy.
2. Leaf: Types, Margin, Base, Venation and Phyllotaxy, Petiole and modifications.
3. Inflorescence: types with examples; Flower: Floral parts, Thalamus and insertion of floral parts, Calyx, Corolla, Aestivation, Perianth, floral diagram and floral formula. Stamen: Types and anther shape. Carpel : types, placentation-types, ovule structure and types; Fruit types with examples.
4. Meristimatic and permanent tissues: Organization of shoot apex (Tunica-corpus concept) and organization of root apex (Korper-Kappe concepts); Structure of dicot and monocot leaf, Kranz anatomy. Structure of Xylem and Phloem tissue; Types and evolution of stele; Vascular bundle -types and function. Root-Stem transition and its significance; Normal and Anomalous secondary growth (citing examples of *Bignonia* and *Dracaena* and *Tinospora* root), different types of wood. Concept and application of Dendrochronology.
5. Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes(uni- and multicellular, glandularand nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation;Anatomical adaptations of xerophytes and hydrophytes.

DC 4: PAPER 8 (Practical)

1. Morphology: Morphological studies (No working out): Different types of phyllotaxy in plants; Types of special inflorescence; Aestivations, Anther types and Placentation; Different types of fruits.
2. Anatomy: Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.

Permanent slides/Micrographs/Photographs

1. Apical meristem of root, shoot and vascular cambium
2. Root: monocot, dicot, secondary growth
3. Stem: monocot, dicot - primary and secondary growth
4. C4 leaves (Kranz anatomy) (Temporary stain mounts and Permanent slide)

Workout and preparation of temporary mounts

1. Anamolous secondry growth in *Bignonia* and *Dracaena* , *Tinospora root*
2. Stomata types; trichomes: non-glandular and glandular
3. Adaptive Anatomy:
   a. Hydrophyte: *Eichhornia*, *Hydrilla* and *Ludwigia adscandens*.
   b. Xerophyte: *Nerium* and *Casuarina*
4. Secretory tissues: raphids, sclerides, aleurone, lithocysts and laticifers.

Suggested Readings

1. Eames, A.J. .....Morphology of Angiosperms [McGraw Hill]
2. Esau, K. .....Plant Anatomy [Wiley Eastern]
3. Fahn, A. .....Plant Anatomy [Pergamon press]
4. Foster, A.S. .....Practical Plant Anatomy [D. Van Nestnand Co.]
5. Ganguly, H.C. & Kar, A.K. .....College Botany Vol. I [New Central Book Agency]
6. Lawrence, G.H.M..... (Glossary) Taxonomy of Vascular Plants [Oxford & IBH]
7. Mauseth, J.D. .....Plant Anatomy [Benjamin Cummings Publications]

8. Mitra, D., Guha, J. & Chowdhury, S.K....Studies in Botany, Vol.I [Moulik Library]
9. Mehra, P.N. .....Evolution of spore through the ages [Palynological Society ofIndia, National Botanic Garden, Lucknow]
10. Nair, P.K.K. .....Pollen Morphology of Angiosperms [Scholar Publication]
11. Erdtman, G. .....Pollen Morphology and Plant Taxonomy [Ielden: E.G. Brill]
12. Faegri, K. & Iverson, J. .....Text Book of Pollen Analysis [Oxford: BlackwellScientific Publication]

Discipline Core (DC)

YEAR 2: SEMESTER III

(Credits: Theory-4, Practical-2)

DC 5: PAPER 9: Plant Systematics

(Theory) (Total Lecture 60)

1. Significance of Plant systematics: Introduction to systematics; Plant identification, Classification, Nomenclature. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access.
2. Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).
3. Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.
4. Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Outline of classification systems of Linnaeus (1753), Bentham and Hooker (1862-1883) upto series and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.
5. Biometrics, numerical taxonomy and cladistics : Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).
6. Phylogeny of Angiosperms:Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).
7. Diagnostic features of Families: **Dicotyledons-** Ranunculaceae, Brassicaceae, Malvaceae, Leguminosae (sensu lato), Apiaceae, Solanaceae, Lamiaceae, Cucurbitaceae, Rubiaceae, Euphorbiaceae, Asteraceae. **Monocotyledons**-Alismataceae, Poaceae, Zingiberaceae and Orchidaceae.

DC5: PAPER 10: (Practical)

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):
Ranunculaceae- *Ranunculus, Delphinium*
Brassicaceae- *Brassica, Alyssum / Iberis*
Malvaceae- *Sida / Abutilon*
Apiaceae- *Coriandrum /Anethum / Foeniculum*
Solanaceae- *Solanum /Physalis/ Nicotiana*
Lamiaceae- *Salvia/Ocimum/ Leucas/Leonurus*
Cucurbitaceae: *Cephalandra/ Nukia*
Rubiaceae: *Dentella/ Spermacoce/Oldenladia*
Euphorbiaceae: *Jatropha / Croton / Acalypha*
Asteraceae- *Sonchus/ Launaea, Vernonia/ Ageratum/ Tridax*

2. Mounting of a properly dried and pressed specimen of at least 20-30 collected Angiospermic plants with herbarium label and arranged according to Bentham and Hookers system of classification.

3. Botanical excursion: Enlistment of plants observed in the field and submission of field note book with 10-25 photographs with ecological notes on the plants observed.

Suggested Readings

1. Lawrence, G.H.M. .....Taxonomy of Vascular Plants [Oxford & IBH]
2. Datta, S.C. .....Systematic Botany [Wiley Eastern]
3. Mukherjee, S. .....College Botany Vol. III [New Central Book Agency]
4. Mitra, D., Guha, J. & Chowdhury, S.K...Studies in Botany, Vol. I [Moulik Library]
5. Naik, V.N. .....Taxonomy of Angiosperms [Tata McGraw Hill]
6. Heywood, V.H. .....Flowering Plants of India [Oxford University Press]
7. Stace, C.A. .....Plant Taxonomy and Biosystematics [Arnold Publishers]
8. Prain, D. .....Bengal Plants Vol. I & II [Bishen Singh, Mahendra Pal Singh]
9. Sivarajan, V.V. .....Introduction to Principles of Plant Taxonomy [Oxford & IBH]

DC 6: PAPER 11: Plant Ecology , Phytogeography and Biodiversity

(Theory) (Total Lecture 60)

1. Introduction : Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.
2. **Soil**: Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development. **Water**: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.
3. **Trophic organization**: basic source of energy, Models of energy flow, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop. **Population ecology:** Characteristics and Dynamics .Ecological Speciation
4. **Plant communities:** Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.
5. **Ecosystems:** Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids. **Functional aspects of ecosystem:** Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.
6. **Phytogeography**: Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.
7. **Plant Biodiversity:** Biodiversity and Conservation: Biodiversity – definition, scope, types (genetic, species and ecosystem), importance and threats; Threatened plants (IUCN Categories); knowledge on Red Data Book; Hotspots.
8. *In situ* and *ex situ* conservation strategies for rare and endangered plants with emphasis on National parks, Sanctuaries and Biosphere reserves, seed banks, cryopreservation in India.

DC 6: PAPER 12: Practical

Plant Ecology and Phytogeography

1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
2. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
3. Determination of dissolved oxygen and dissolved carbon dioxide of water samples from polluted and unpolluted sources.
4. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
5. Study of morphological adaptations of hydrophytes and xerophytes (four each).
    a. Hydrophyte: *Eichhornia, Nymphaea, Hydrilla, Pistia, Ludwigia adscandens*.
    b. Xerophyte: *Nerium, Casuarina, Opuntia, Euphorbia tirucauli*.

6. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
7. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
8. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.

7. Botanical excursion: Field visit to familiarize students with ecology of different sites.

Suggested readings

1. Odum, E.P. .....Fundamentals of Ecology [Saunders]
2. Ambasht, R.S and Ambasht, N.K .....A Text book of plant Ecology [CBS Publ.]
3. Sukla, R.S. & Chandal, P.S. .....Plant Ecology [S. Chand & Co.]
4. Verma, P.S. & Agarwal, V.K. .....Concept of Ecology [S. Chand & Co.]
5. Kumar, H.D. .....Modern Concept of Ecology [Vikas Pub House]
6. Dhaliwal, G.S., Sangha, G.S and Ralhan, P.K .....Fundamentals of EnvironmentalSciences [Kalyani Pub.]
7. Asthana, D.K and Asthana M. .....Environmental Problems and Solutions[S. Chand & Co.]
8. Cox, C.B & Moore, P.D .....Biogeography –An Ecological and EvolutionaryApproach [Blackwell Scientific Publ.]
9. Mani, M.S. .....Biogeography of India [Springer-Verlag]
10. Mitra, D., Guha, J. & Chowdhury, S.K.....Studies in Botany Vol. II[Moulik Library]
11. Sharma, P.D. .....Elements of Ecology [Rastogi Publ.]

DC 7. PAPER 13: Economic botany

(Theory) (Total Lecture 60)

1. Origin of Cultivated Plants: Concept of Centres 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.

2. **Cereals:** Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

3. **Legumes:** Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

4. **Sources of sugars and starches:** Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

5. **Spices:** Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper.

6. **Beverages:** Tea, Coffee (morphology, processing & uses)

7. **Sources of oils and fats:** General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

8. **Natural Rubber:** Para-rubber: tapping, processing and uses.

9. **Drug-yielding plants:** Therapeutic and habit-forming drugs with special reference to C*inchona*, *Digitalis* and *Cannabis*; Tobacco (Morphology, processing, uses and health hazards).

10. **Timber plants:** General account with special reference to teak and pine.

11. **Fibers:** Classification based on the origin of fibers; Cotton and Jute (morphology, extraction and uses)

DC 7: PAPER 14: Practical

1. **Cereals**: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests: Qualitative: Ca, Mg, Fe and S); Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legumes**: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests: : Qualitative: Ca, Mg, Fe and S).
3. **Sources of sugars and starches**: Sugarcane (habit sketch; cane juice- micro-chemical tests: Qualitative: Ca, Mg, Fe and S), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains).
4. **Spices:** Black pepper, Fennel and Clove (habit and sections).
5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats**: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants**: Habit sketch of *Rosa, Vetiveria, Santalum* and *Eucalyptus* (specimens/photographs).
8. **Drug-yielding plants**: Specimens of *Digitalis, Papaver* and *Cannabis.*
9. **Woods:** *Tectona, Pinus*: Specimen, (Types of section of wood specimen)
10. **Fiber-yielding plants**: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

11. Botanical excursion: Field visit to plantation sites/fields to familiarize students with cultivation practices and submission of collected specimen (minimum of 10 specimen with proper documents and identification covering cereals, Legumes, spices, Beverages, fiber yielding or wood)

Suggested readings

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Discipline Core (DC)

YEAR 2: SEMESTER IV

(Credits: Theory-4, Practical-2)

DC 8: PAPER 15: Cell biology and Plant Breeding (Theory) (60Lectures)

Cell biology

1. **The cell:** Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).
2. **Cell wall and plasma membrane:** Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid, mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.
3. **Cell organelles: Nucleus:** Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.
4. **Chloroplast, mitochondria and peroxisomes:** Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.
5. **Cytoskeleton:** Role and structure of microtubules, microfilaments and intermediary filament..
6. **Endomembrane system:** Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.
7. **Cell division:** Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle-checkpoints, role, of protein kinases.

Plant Breeding

1. Concept of plant breeding; Significance and role in crop improvement.
2. Types of variety selection – mass selection, pure line selection, clonal selection, bulk and pedigree selection and hybridization.
3. Heterosis and Hybrid vigour; Male sterility in plants- types and application.

DC 8: PAPER 16: Practical

1. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/Crinum
2. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
3. Study of cell and its organelles with the help of electron micrographs.
4. Chromosome preparation: Pre-treatment, Fixation, Staining, Squash and Smear preparation, Preparation of permanent slides. Study of Mitotic Chromosomes.
5. Metaphase chromosome preparation, free hand drawing, determination of 2n number and comment on chromosome morphology of *Allium cepa*.
6. Determination of mitotic index in pre-fixed root tips of *Allium cepa.*
7. Identification from permanent slides : Mitosis – (i) normal stages, (ii) abnormal stages- early separation, late separation, multipolarity , sticky bridge, laggard, fragmentation, (ii) pollen mitosis.
8. Emasculation of flower: Demonstration.

Suggested Readings

1. Cooper, G.M. .....The Cell - A Molecular Approach [ASM Press]
2. De Robertis, E.D.P. & De Robertis, E.M.M. .....Cell and molecular Biology [Waverly Pvt. Ltd. for Lea & Fabiger]
3. Karp, G….....Cell and Molecular Biology: Concepts and Experiments [John Wiley & Sons. Inc]
4. Powar, C.B. .....Cell Biology [Himalaya Publishing House]
5. Verma, P.S. & Agarwal, V.K. .....Concept of Cell Biology [S. Chand & Co.]
6. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
7. Allard, R.W. .....Principles of Plant Breeding [John Wiley]
8. Chawdhuri, H.K. .....Elementary Principles of Plant Breeding [Oxford & IBH]
9. Poehlman, J.M. & Barthakur, D. .....Plant Breeding [Oxford & IBH]
10. Singh, B.D. .....Plant Breeding: Principles and Methods [Kalyani Publishers]

DC 9: PAPER 17: Genetics and Biostatistics
(Theory) (60 Lectures)

Genetics

1. **Mendelian genetics and its extension**: Mendelism: Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and co-dominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits.
2. **Linkage, crossing over and chromosome mapping:** Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.
3. **Extrachromosomal Inheritance**: Basic concepts with examples in chloroplast and mitochondria
4. **Variation in chromosome number and structure:** Deletion, Duplication, Inversion, Translocation,
5. Position effect, Euploidy and Aneuploidy
6. **Gene mutations:** Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Baseanalogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation.DNA repair mechanisms.
7. **Fine structure of gene:** Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.
8. Operon concept : Lac Operon and Trp- Operon
9. **Population and Evolutionary Genetics:** Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Biostatistics

1. Introduction to Biostatistics: Characteristics, Usefulness and Limitation, Types of Data.
2. Sampling methods-concept of sampling of population, measures of central tendency and dispersal: determination of mean, mode, median, variance, standard deviation and standard error.
3. Rules of probability (Addition and Multiplication theorem), Null-hypothesis, Tests of significance: chi-square test, t-test (student and paired t-test).
4. Correlation and Regression.

DC 9: PAPER 18: Practical

1. Introduction to chromosome preparation: Pre-treatment, Fixation, Staining, Squash and Smear preparation.
2. Preparation of permanent slides Study of meiotic chromosome: Smear preparation of meiotic cells, identification of different stages and free hand drawing from flower buds: *Allium cepa*.
3. Identification from permanent slides : Meiosis – (i) normal stages (ii) abnormal stages – laggard, anaphase bridge, ring chromosome (*Rhoeo discolor*)
4. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Univariate analysis of statistical data: Statistical tables, mean mode, median, standard deviation, and standard error (using seedling population/leaflet size).

Suggested Readings

1. Gardner, E.J., Simmons, M.J. & Snustad, D.P...Principles of Genetics [John Wiley]
2. Gupta, P.K. .....Genetics [Rastogi Publications]
3.Klug, W.S. & Cummings, M.R. .....Concept of Genetics [Prentice Hall]
4.Lewin, B. .....Genes (any one: - VI or VII or VIII or IX) [Oxford University Press]
5.Russell, P.J. .....*i*Genetics [Benjamin / Cumming Publ. Co.]
6. Stent, G.S. & Calendar, R. ...Molecular Genetics-An Introductory Narrative [CBS]
7. Stickberger, M.W. .....Genetics [McMillan]
8. Weaver, R.F. & Hedrick, P.W. .....Genetics [WCB Publications]
9. Sokal, R.R. & Rohlf, F.J. .....Introduction to Biostatistics [W H Freeman]
10P K Banerjee .....Introduction to Biostatistics [S. Chand]

DC 10: PAPER 19: Reproductive Biology of Angiosperms (Theory) (60 Lectures)

1. **Introduction:** History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P.Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.
2. **Reproductive development:** Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.
3. **Anther and pollen biology:** Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; **Palynology and scope** (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.
4. **Ovule:** Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.
5. **Pollination and fertilization:** Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.
6. **Self incompatibility:** Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination.
7. **Embryo, Endosperm and Seed:** Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship;

Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms.

DC 10: PAPER 20: Practical

1. Slides/Micrographs of Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages and Male Germ Unit.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph).
3. Pollen viability: Tetrazolium test, Germination: Calculation of percentage germination in different media using hanging drop method.
4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (Permanent slides/specimens/photographs, Micrographs).
5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
6. Intra-ovarian pollination; Test tube pollination through photographs. (Cucumber seed)
7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
8. Embryogenesis: Study of development of dicot embryo through permanent slides; Dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. ..... The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. ..... Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V.....Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. l ..... Embryology of Angiosperms, Springer-Verlag, Netherlands.
5. Mehra, P.N. .....Evolution of spore through the ages [Palynological Society ofIndia, National Botanic Garden, Lucknow]
6. Nair, P.K.K. .....Pollen Morphology of Angiosperms [Scholar Publication]
7. Erdtman, G. .....Pollen Morphology and Plant Taxonomy [Ielden: E.G. Brill]
8. Faegri, K. & Iverson, J. .....Text Book of Pollen Analysis [Oxford: BlackwellScientific Publication]

Discipline Core (DC)

YEAR 3: SEMESTER V

(Credits: Theory-4, Practical-2)

DC 11. PAPER 21: Plant Physiology
(Theory) (60 Lectures)

1. **Plant-water relations:** Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement. Soil-Plant-Atmosphere continuum concept, Cavitation and ambolism.
2. **Mineral nutrition:** Essential and beneficial elements, macro and micronutrients, mineral deficiency symptoms, roles of essential elements, chelating agents. **Nutrient Uptake:** Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems,proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.
3. **Translocation in the phloem:** Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.
4. **Transpiration: Stomata** - micellation of guard cell; Role of CO2, K+ - ion, blue light & abscisic acid in stomatal movement; Anti-transpirant.
5. **Plant growth regulators:** Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.
6. **Physiology of flowering:** Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy; **Phytochrome, crytochromes and phototropins:** Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.
7. **Seed Dormancy:** Types, causes and methods of breaking seed dormancy.

DC-11: PAPER 22: Practical

1. Determination of stomatal frequency and rate of transpiration per stomata per hour.
2. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
3. Measurement of oxygen uptake by respiring tissue (per gram / hr.) by germinating seeds.
4. Measurement of osmotic pressure in the leaf cells of *Rhoeo discolor* by plasmolytic method.
5. Determination of water potential / Osmotic pressure of given tissue (potato tuber) by weight method.
6. Determination of R.Q. of germinating seeds by Ganong' respirometer or respiroscope.
7. Effect of detergent (SDS) on the permeability of plasma membranes.
8. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).

Suggested Readings

1. Hopkins, W.G. & Hüner, M.P. .....Introduction to Plant Physiology [John Wiley & Sons.]
2. Jain, V.K. .....Fundamentals of Plant Physiology [S. Chand & Co.]
3. Lehninger, A.L., Nelson, D.L. & Cox, M.M. .....Principles of Biochemistry [CBS]
4. Mukherji, S. & Ghosh, A. .....Plant physiology [New central Book Agency]

5. Pandey, S.N & Sinha, B.K. .....Plant Physiology [Vikas Publ. House]
6. Salisbury, F.B. & Ross, C.W. .....Plant Physiology [Wordsworth Publ. Co.]
7. Singhal, G.S. ....Concepts Photobiology, Photosynthesis & photomorphogenesis [Narosa Publishing House]
8. Sinha, R.K. .....Modern Plant Physiology [Narosa Publishing House]
9. Taiz, L & Zeiger, E. .....Plant Physiology [Sinauser Associates Inc. Publishers]
10. Verma, S.K ....A Text book of Plant Physiology & Biochemistry [S. Chand & Co.]
11. Voet, D. & Voet, J.G. .....Biochemistry [John Wiley]
12. Wilkins, M.B. .....Advanced Plant Physiology [ELBS, Longman]

DC 12: PAPER 23: Plant Metabolism
(Theory) (60 Lectures)

1. **Concept of Metabolism in plants**: Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).
2. **Carbon assimilation**: Historical background, photosynthetic pigments: Structure of chlorophyll a & b, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration,C4 pathways; efficiency of C3 & C4 plants on crop productivity; CAM and its ecological significance. Crassulacean acid metabolism; Factors affecting CO_2 reduction.
3. **Carbohydrate metabolism**: Synthesis and catabolism of sucrose and starch.
4. **Carbon Oxidation**: Glycolysis and its significance, fate of pyruvate, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.
5. **ATP-Synthesis**: Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.
6. **Lipid metabolism:**Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.
7. **Nitrogen metabolism:** Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.
8. **Mechanisms of signal transduction:** Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

DC 12: PAPER 24: Practical

1. Chemical separation of photosynthetic pigments by paper chromatography.
2. Experimental demonstration of Hill's reaction.
3. Demonstration of absorption spectrum of photosynthetic pigments.
4. To study the effect of light quality on the rate of photosynthesis.
5. Effect of carbon dioxide on the rate of photosynthesis. (varying HCO- 3 concentration using bicarbonate in an aquatic plant to find out the optimum and toxic concentration)
6. To compare the rate of respiration in different parts of a plant (Flower, leaf, buds etc)
7. Determination of R.Q. of germinating seeds by Ganong' respirometer or respiroscope.
8. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.

Demonstration:

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).
3. Bolting experiment/*Avena* coleptile bioassay (demonstration).

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.
2. U.S.A. 4th edition.
3. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development.
4. Sinauer Associates Inc. USA. 6th edition.
5. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

Discipline Core (DC)

YEAR 3: SEMESTER VI

(Credits: Theory-4, Practical-2)

DC 13: PAPER 25: Biomolecules (Biochemistry)

(Theory) (Total Lectures 60)

1. Biomolecules: Types and significance of chemical bonds (Covalent, non-covalent & hydrogen bonds, van der Waals interactions); Structure and properties of water; pH and buffers.
2. Carbohydrates: Nomenclature and classification; Monosaccharides ; Disaccharides; Oligosaccharides and polysaccharides.
3. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; saturated and unsaturated fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.
4. Proteins: Structure of amino acids and classification; Levels of protein structure-primary, secondary, tertiary and quarternary; Protein denaturation and biological roles of proteins.
5. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.
6. Bioenergenetics: Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.
7. Enzymes: Definition**,** Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group;Classification of enzymes; Features of active site, substrate specificity, mechanism of action(activation energy, lock and key hypothesis, induced - fit theroy), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

DC 13: PAPER 26: Practical

1. Detection of nature of carbohydrate- glucose, fructose and starch from laboratory samples.
2. Estimation of amino-nitrogen in an amino acid (glycine) by formol titration method.
3. Estimation of glucose by Benedict's quantitative reagent.
4. Estimation of titrable acidity from lemon.
5. Estimation of catalase activity in plant samples.
6. Estimation of urease activity in plant samples.
7. Colorimetric estimation of protein using Folin-Ciocalteu phenol reagent.

Suggested Readings

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. .....Biochemistry [Freeman Publ.]
2. Conn, E.E., Stumpf, P.K., Bruening, G. & Doi, R.H. .....Outlines of Biochemistry [John Wiley & Sons]
3. Elliot, W.H. & Elliot, D.C. .....Biochemistry and Molecular Biology [Oxford University Press]
4. Goodwin, T.W. & Mercer, E.I. .....Introduction to Plant Biochemistry [Oxford: Pergamon]
5. Lea, P.J. & Leegwood, R.C. .....Plant Biochemistry and Molecular Biology [John Wiley]
6. Lehninger, A.L., Nelson, D.L. & Cox, M.M. .....Principles of Biochemistry [CBS]
7. Verma, S.K ....A Text book of Plant Physiology & Biochemistry [S. Chand & Co.]
8. Voet, D. & Voet, J.G. .....Biochemistry [John Wiley]

DC 14: PAPER 27: Plant Biotechnology

(Theory) (60 Lectures)

1. **Plant Tissue Culture** Historical perspective; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Composition of tissue culture media; Nutrient and hormone requirements (role of vitamins and hormones).
2. Micropropagation: methods and stages, advantages, disadvantages and application, organogenesis and embryogenesis (zygotic and somatic, induction of somatic embryogenesis, role of plant growth regulators, application – synthetic seeds); callus culture; application of plant tissue culture in agriculture and forestry.
3. Protoplast isolation, culture and fusion; Application of Tissue culture applications (micropropagation, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).
4. **Recombinant DNA technology :** Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).
5. **Gene Cloning:** Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediatedgene cloning; Gene Construct; construction of genomic and cDNA libraries, screeningDNA libraries to obtain gene of interest by genetic selection; complementation, colonyhybridization; PCR
6. **Methods of gene transfer:** Brief idea about different methods of gene transfer,*Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).
7. **Applications of Biotechnology:** Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase,); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

DC 14: PAPER 28: Practical

1. **Demonstrations**
    a. Preparation of MS medium.(Demonstration)
    b. *In vitro* sterilization and inoculation methods using leaf and nodal explants
2. **Demonstration through photographs**
    a. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds
    b. Study of methods of gene: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
    c. Study of steps of genetic engineering for production of Bt cotton and Golden rice.
3. Isolation of protoplasts (Demonstration)/visuals
4. Construction of restriction map of circular and linear DNA from the data provided.
7. Isolation of Plant DNA
8. Gel Electrophoresis of plant Genomic DNA

Suggested reading

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier
2. Science Amsterdam. The Netherlands.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of
4. recombinant DNA. ASM Press, Washington.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication
6. House Pvt. Ltd., New Delhi. 5th edition.
7. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K.
8. 5th edition.
9. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and
10. Applications. John Wiley & Sons Inc. U.S.A.
11. Channarayappa .....Molecular Biotechnology: Principles and Practices [Universities Press]
12. Dubey, R.C. .....Biotechnology [S. Chand & Co.]
13. Gamborg, O.L. & Philips, G.C. .....Plant Cell, Tissue and Organ Culture -Fundamental Method [Narosa Publications]
14. Razdan, M.K. .....An Introduction to Plant Tissue Culture [Oxford & IBH]

DISCIPLINE PLINE SPECIFIC ELECTIVE (DSE)

Analytical Techniques in Plant Sciences
Bioinformatics
Stress Biology
Plant Breeding
Natural Resource Management
Industrial and Environmental Microbiology

DSE 4: Project : Topics to be decided as per the theoretical syllabus

Discipline Specific Elective

1. Analytical Techniques in Plant Sciences

(Credits: Theory-4, Practical-2)

THEORY (Lectures: 60)

1. **Imaging and related techniques:** Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Applications of fluorescence microscopy: Principle of Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.
2. **Cell fractionation:** Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.
3. **Radioisotopes:** Definition, Use in biological research, auto-radiography, pulse chase experiment.
4. **Spectrophotometry:** Principle and its application in biological research.
5. **Chromatography:** Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.
6. **Characterization of proteins and nucleic acids:** Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS PAGE
7. **Biostatistics:** Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR **through photographs**.
2. Demonstration of ELISA.
3. To separate amino acids by thin layer chromatography.
4. To estimate protein concentration through Lowry's methods.
5. To separate proteins using SDS PAGE.
6. To separation DNA (marker) using PAGE.
7. Study of different microscopic techniques using photographs/micrographs (Negative staining, positive staining, fluorescence and FISH).
8. Preparation of permanent slides (double staining).

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Discipline Specific Elective
Bioinformatics
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. **Introduction to Bioinformatics:** Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.
2. **Databases in Bioinformatics:** Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.
3. **Biological Sequence Databases:** National Center for Biotechnology Information (NCBI): Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank). Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.
4. **Sequence Alignments:** Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).
5. **Molecular Phylogeny:** Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.
6. Applications of Bioinformatics in various fields.

Practical

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases in *fasta format* (NCBI)
3. Sequence alignment. (Using Mega 4 bioinformative tool)
4. Sequence homology and Gene annotation. CLUSTAL-W
5. Construction of phylogenetic tree.(Neighbor joining, Bootstraps)

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. _II Edition. Benjamin Cummings.

Discipline Specific Elective
Stress Biology
Credits: Theory 4, Practical 2
Lectures: 60
Theory

1. Defining plant stress: Acclimation and adaptation.

2. Environmental factors: Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by Jasmonates.

3. **Stress sensing mechanisms in plants:** Calcium modulation, Phospholipid signaling

4. Developmental and physiological mechanisms that protect plants against environmental stress: Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmotic adjustment; Compatible solute production.

5. Reactive oxygen species–Production and scavenging mechanisms.

Practical

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Quantitative estimation and analysis of catalase.
4. Quantitative estimation and analysis of glutathione reductase.
5. Estimation of superoxide anions.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley andSons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology andDevelopment. Sinauer Associates Inc. USA. 6th edition.

Discipline Specific Elective
Plant Breeding
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. Plant Breeding: Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.
2. Methods of crop improvement: Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.
3. Quantitative inheritance: Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings.Monogenic vs polygenic Inheritance.
4. Inbreeding depression and heterosis: History, genetic basis of inbreeding depression and heterosis; Applications.
5. Crop improvement and breeding: Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

Plant Breeding

1. Concept of plant breeding; Significance and role in crop improvement.
2. Types of variety selection – mass selection, pure line selection, clonal selection, bulk and pedigree selection and hybridization.
3. Heterosis and Hybrid vigour; Male sterility in plants- types and application.

Practical

1. Study of germplasm.
2. Study of floral structure of self-pollinated and cross pollinated crops.
3. Emasculation and hybridization techniques in self and cross pollinated crops.
4. Artificial pollination in self-pollinated crop (any one crop).
5. Experiments on epistatic interactions and data analysis.
6. Study on probability and Chi-square test and heritability analysis.

Suggested Readings

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2ndedition.
3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

Discipline Specific Elective
Natural Resource Management
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. Natural resources: Definition and types.
2. Sustainable utilization: Concept, approaches (economic, ecological and socio-cultural).
3. Land: Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.
4. Water: Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.
5. Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).
6. Forests: Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.
7. Energy: Renewable and non-renewable sources of energy
8. Contemporary practices in resource management: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.
9. National and international efforts in resource management and conservation

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.

Suggested Readings

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.

Discipline Specific Elective

Industrial and Environmental Microbiology
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. **Scope of microbes in industry and environment**
2. **Bioreactors/Fermenters and fermentation processes:** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
3. **Microbial production of industrial products:** Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)
4. **Microbial enzymes of industrial interest and enzyme immobilization:** Microorganisms for industrial applications_and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**).**
5. **Microbes and quality of environment:** Distribution of microbes in air; Isolation of microorganisms from soil, air and water.
6. **Microbial flora of water:** Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.
7. **Microbes in agriculture and remediation of contaminated soils.** Biological Nitrogen fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Determination of dissolved oxygen and dissolved carbon dioxide of water samples from polluted and unpolluted sources.
4. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.

GENERIC ELECTIVES (GE)

Biodiversity (Microbes, Algae, Fungi and Archegoniate)
Plant Ecology and Taxonomy
Plant Anatomy and Embryology
Plant Physiology and Metabolism
Economic Botany and Biotechnology
Environmental Biotechnology

Generic Elective
Biodiversity (Microbes, Algae, Fungi and Archegoniate)
(Credits: Theory-4, Practical-2)
THEORY Lectures: 60

1. **Microbes:**

   Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and Lysogenic cycle, RNA virus (TMV); Economic importance.

   Bacteria – Discovery, General characteristics and cell structure; Cell wall – chemical structure and differences between Gram +ve & Gram –ve bacteria; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance with respect to uses of microbes as Biofertilizer, Bioplastic and Biopesticides.

2. **Algae:** General characteristics; Ecology and distribution; Range of thallus organization and reproduction; classification of Lee (only upto groups) with characteristic features of each group; Morphology and life-cycles of the following: *Nostoc*, *Oedogonium, and Chara*. Economic importance of algae.

3. **Fungi:** Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction. Classification according to Ainsworth 1973; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Ascobolus* (Ascomycota), *Agaricus* (Basidiomycota).

   Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.

4. **Introduction to Archegoniate:** Unifying features of archegoniates, Transition to land habit, Alternation of generations.

5. **Bryophytes:** General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Marchantia,Anthoceros* and *Funaria*.(Developmental details not to be included). Ecology and economic importanceof bryophytes with special mention of *Sphagnum*.

6. **Pteridophytes:** General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes. Morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*.(Developmental details not to be included).

7. **Gymnosperms:** General characteristics; Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included). Ecological and economical importance.

Practical

1. Electron Micrographs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Observation of Bacteriods in root Nodule/Curd (Simple staining: Methylene blue).
3. Study of vegetative and reproductive structures of *Nostoc, Oedogonium (*Macrandrous*), and Chara* through temporary preparations and permanent slides.
4. Asexual stage from temporary mounts of *Rhizopus, Ascobolous/ Peziza* and *Agaricus*.
5. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
6. Type study using semi permanent mounts: *Marchantia* (antheridial and archegonial heads); *Anthoceros* (Sporophyte); *Funaria* (Capsule)

7. Type study using semi permanent mounts: *Selaginella*- morphology; Stem (T.S), Strobilus (L.S); *Equisetum*- morphology, internode (T.S), strobilus (L.S). *Pteris*- morphology, t.s. rachis (T.S), sporophyll (L.S), Morphological studies of Megasporophyll and Microsporophyll.
8. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root (T.S) Leaflet (T.S)
9. *Pinus*- morphology (long and dwarf shoots, Needle (T.S), Morphological studies of Male and Female Cones

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

Generic Elective
Plant Ecology and Taxonomy
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

A. Ecology

1. Introduction: Ecological factors- Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

2. Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types

3. Ecosystem: Structure; energy flow trophic organization; Food chains and food webs, Ecological pyramids, production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

4. Phytogeography: Principle biogeographical zones; Endemism

B. Taxonomy

1. Introduction to plant taxonomy: Identification, Classification, Nomenclature.

2. Identification: Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

3. Taxonomic hierarchy: Ranks, categories and taxonomic groups

4. Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

5. Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).

6. Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

7. Diagnostic features of Families: Dicotyledons: Brassicaceae, Malvaceae, Leguminosae (sensu lato), Euphorbiaceae, Solanaceae, Lamiaceae, Cucurbitaceae, Asteraceae; **Monocotyledons**- Poaceae, Liliaceae, and Orchidaceae.

Practical

1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
2. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
3. Determination of dissolved oxygen and dissolved carbon dioxide of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes and xerophytes (four each).

a. Hydrophyte: *Eichhornia, Nymphaea, Hydrilla, Pistia, Ludwigia adscandens*.

b. Xerophyte: *Nerium, Casuarina, Opuntia, Euphorbia tirucauli*.

5. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):

   Ranunculaceae- *Ranunculus, Delphinium*
   Brassicaceae- *Brassica, Alyssum / Iberis*
   Malvaceae- *Sida / Abutilon*
   Apiaceae- *Coriandrum /Anethum / Foeniculum*
   Solanaceae- *Solanum /Physalis/ Nicotiana*
   Lamiaceae- *Salvia/Ocimum/ Leucas/Leonurus*
   Cucurbitaceae: *Cephalandra/ Nukia*
   Rubiaceae: *Dentella*/ *Spermacoce/Oldenladia*Euphorbiaceae: *Jatropha / Croton / Acalypha*
   Asteraceae- *Sonchus/ Launaea, Vernonia/ Ageratum/ Tridax*

13. Mounting of a properly dried and pressed specimen of at least 20-30 collected Angiospermic plants with herbarium label and arranged according to Bentham and Hookers system of classification.

Suggested Readings

1. Odum, E.P. .....Fundamentals of Ecology [Saunders]
2. Ambasht, R.S and Ambasht, N.K .....A Text book of plant Ecology [CBS Publ.]
3. Kumar, H.D. .....Modern Concept of Ecology [Vikas Pub House]
4. Mukherjee, S. .....College Botany Vol. III [New Central Book Agency]
5. Mitra, D., Guha, J. & Chowdhury, S.K...Studies in Botany, Vol. I [Moulik Library]
6. Heywood, V.H. .....Flowering Plants of India [Oxford University Press]
7. Stace, C.A. .....Plant Taxonomy and Biosystematics [Arnold Publishers]
8. Prain, D. .....Bengal Plants Vol. I & II [Bishen Singh, Mahendra Pal Singh]
9. Sivarajan, V.V. .....Introduction to Principles of Plant Taxonomy [Oxford & IBH]

Generic Elective
Plant Anatomy and Embryology
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. **Meristematic and permanent tissues:** Root and shoot apical meristems; Simple and complex tissues
2. **Organs:** Structure of dicot and monocot root stem and leaf.
3. **Secondary Growth:** Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)
4. **Adaptive and protective systems:** Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.
5. **Structural organization of flower:** Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.
6. **Pollination and fertilization:** Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.
7. **Embryo and endosperm:** Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship
8. **Apomixis and polyembryony:** Definition, types and Practical applications

Practical

1. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*; Secondary: *Helianthus* (Work out).
2. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (Work out).
3. Leaf: Dicot and Monocot leaf (only Permanent slides).
4. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem) (Work out)
5. Structure of anther (young and mature), Tapetum (amoeboid and secretory) (Permanent slides).
6. Ultrastructure of mature egg apparatus cells through electron micrographs.
7. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
8. Dissection of embryo/endosperm from developing seeds (Work out)

Suggested Readings

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
3. Mitra, D., Guha, J. & Chowdhury, S.K....Studies in Botany, Vol.I [Moulik Library]
4. Nair, P.K.K. .....Pollen Morphology of Angiosperms [Scholar Publication]

Generic Elective
Plant Physiology and Metabolism
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. **Plant-water relations:** Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.
2. **Mineral nutrition:** Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.
3. **Translocation in phloem**: Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading
4. **Photosynthesis:** Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C_3, C_4 and CAM pathways of carbon fixation; Photorespiration.
5. **Respiration:** Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate,Oxidative Pentose Phosphate Pathway.
6. **Enzymes:** Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.
7. **Nitrogen metabolism:** Biological nitrogen fixation; Nitrate and ammonia assimilation.
8. **Plant growth regulators:** Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.
9. **Plant response to light and temperature:** Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

Practical

1. Determination of stomatal frequency and rate of transpiration per stomata per hour.
2. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
3. Measurement of oxygen uptake by respiring tissue (per gram / hr.) by germinating seeds.
4. Measurement of osmotic pressure in the leaf cells of *Rhoeo discolor* by plasmolytic method.
5. Effect of carbon dioxide on the rate of photosynthesis. (varying HCO_3^- concentration using bicarbonate in an aquatic plant to find out the optimum and toxic concentration)
6. Comparison of the rate of respiration in any two parts of a plant.

Suggested Readings

14. Sinha, R.K. .....Modern Plant Physiology [Narosa Publishing House]
15. Taiz, L & Zeiger, E. .....Plant Physiology [Sinauser Associates Inc. Publishers]
16. Verma, S.K ....A Text book of Plant Physiology & Biochemistry [S. Chand & Co.]
17. Voet, D. & Voet, J.G. .....Biochemistry [John Wiley]
18. Wilkins, M.B. .....Advanced Plant Physiology [ELBS, Longman]
19. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

Generic Elective
Economic Botany and Plant Biotechnology
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

1. **Origin of Cultivated Plants:** Concept of centre of origin, their importance with reference to Vavilov's work.
2. **Cereals :** Wheat -Origin, morphology, uses.
3. **Legumes:** General account with special reference to Gram and soybean.
4. **Spices:** General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses).
5. **Beverages:** Tea (morphology, processing, uses)
6. **Oils and Fats:** General description with special reference to groundnut/Mustard oil
7. **Fiber Yielding Plants:** General description with special reference to Jute (Botanical name, family, part used, morphology and uses)
8. **Introduction to biotechnology**
9. **Plant tissue culture:** Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications
10. **Recombinant DNA Techniques:** Blotting techniques: Northern, Southern and Western Blotting, DNA Finger printing; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Concepts of Hybridoma and monoclonal antibodies, Principle and Application of ELISA and Immunodetection in management of plant diseases.

Practical

1. Study of economically important plants : Wheat, Gram, Soybean, Black pepper, Clove
2. Tea, Cotton, Groundnut through specimens, sections and microchemical tests
3. Detection of Sugar and proteins from cereals and pulses
4. Familiarization with basic equipments in tissue culture.
5. Study through photographs: Anther culture, somatic embryogenesis, endosperm and
6. embryo culture; micropropagation.
7. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

Suggested Readings

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India
2. Ltd., New Delhi. 4thedition.
3. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice.
4. Elsevier Science Amsterdam. The Netherlands.
5. Dubey, R.C. .....Biotechnology [S. Chand & Co.]
6. Gamborg, O.L. & Philips, G.C. .....Plant Cell, Tissue and Organ Culture -Fundamental Method [Narosa Publications]
7. Razdan, M.K. .....An Introduction to Plant Tissue Culture [Oxford & IBH]

Skill Enhancement Courses

Floriculture
Mushroom Culture Technology
Biofertilizers
Ethnobotany
Plant Diversity and Human Welfare
Medicinal Botany
Herbal Technology

Skill Enhancement Course

Floriculture

(Credits: 2)

Lectures: 30

1. **Introduction:** History of gardening; Importance and scope of floriculture and landscape gardening. Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators.

2. **Ornamental Plants:** Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.

3. **Landscaping Places of Public Importance:** Landscaping highways and Educationalinstitutions.

4. **Commercial Floriculture**: Factors affecting flower production; Production andpackaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation ofImportant cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous,Marigold,Rose, Lilium, Orchids).
5. Diseases and Pests of Ornamental Plants.

Suggested Readings

1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

Skill Enhancement Course
Mushroom Culture Technology
(Credits: 2)
Lectures: 30

1. **Introduction:** History, Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.

2. **Cultivation Technology :** Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag.

3. **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
4. Low cost technology, Composting technology in mushroom production.

5. Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

6. Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level._Cost benefit ratio - Marketing in India and abroad, Export Value.

Suggested Readings

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,
4. Delhi.
5. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

Skill Enhancement Course
Biofertilizers
(Credits: 2)
Lectures: 30

1. General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

2. *Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.*Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

3. Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

4. Plant Growth Promoting Rhizobacteria (PGPR) and Plant Growth Promoting Fungi (PGPF): Characterization, mode of action and effect on plant growth and disease suppression. Induction of resistance in host against plant pathogens-mechanism and pathway involved.

5. Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence anddistribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation andinoculum production of VAM, and its influence on growth and yield of crop plants.

6. Organic farming – Green manuring and organic fertilizers, Recycling of biodegradablemunicipal, agricultural and Industrial wastes – biocompost making methods, typesand method of vermicomposting – field Application.

Suggested Readings

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, NewDelhi.
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 AktaPrakashan, Nadiad
7.

Skill Enhancement Course
Ethnobotany
(Credits 2)
Lectures: 30

1. **Ethnobotany:** Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.

2. **Methodology of Ethnobotanical studies:** a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

3. **Role of ethnobotany in modern Medicine**: Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) (a) Azadiractha indica; (b) Ocimum sanctum; (c) Vitex negundo; (d) Gloriosa superb; (e) Tribulus terrestris; (f) Pongamia pinnata; (g) Cassia auriculata; (h) Indigofera tinctoria. Role of ethnobotany in modern medicine with special example Rauvolfia sepentina, Trichopus zeylanicus, Artemisia, Withania. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).

4. **Ethnobotany and legal aspects:** Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Suggested Readings

1. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi – 1981 Lone et al,. Palaeoethnobotany
3. S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.
4. S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.
5. Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – Chichester
6. Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra
7. Pradesh, India.Botanical Survey of India. Howrah._8) Rajiv K. Sinha – Ethnobotany The
8. Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996_9)

Skill Enhancement Course
Plant Diversity and Human Welfare
(Credits 2)
Lectures: 30

1. **Introduction:** Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for evaluation, Uses of plants, Uses of microbes.

2. **Loss of Biodiversity:** Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss,

3. **Management of Plant Biodiversity:** Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

4. **Conservation of Biodiversity:** Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Socialapproaches to conservation, Biodiversity awareness programmes, Sustainable development.

5. **Role of plants in relation to Human Welfare**; a) Importance of forestry theirutilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d)Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.

Suggested Readings

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles andPractices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi

Skill Enhancement Course
Medicinal Botany
(Credits 2)
Lectures: 30

1. History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridoshaconcepts, Rasayana, plants used in ayurvedic treatments, Siddha: Origin of Siddha medicinalsystems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

2. Conservation of endangered and endemic medicinal plants. Definition: endemic andendangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacredgroves, National Parks; Ex situ conservation: Botanic Gardens, Ethnomedicinal plantGardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification,important components of a nursery, sowing, pricking, use of green house for nurseryproduction, propagation through cuttings, layering, grafting and budding.

3. Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. Folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

Suggested Readings

1. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.

2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.

Skill Enhancement Course
Herbal Technology
(Credits 2)
Lectures: 30

1. Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage -marketing and utilization of medicinal plants.
2. Pharmacognosy - systematic position medicinal uses of the following herbs in curingvarious ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.

3. Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).

4. Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation -Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).

5. Medicinal plant banks micro propagation of important species (*Withania somnifera*,Neem and Tulsi-Herbal foods-future of pharmacognosy)

Suggested Readings

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R,New Delhi.
2. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International
3. Book _Distributors.
4. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.
5. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994.
6. Oxford IBH _publishing Co.
7. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi.
8. Principles of Ayurveda, Anne Green, 2000. Thomsons, London.
9. Pharmacognosy, Dr.C.K.Kokate et al. 1999. Nirali Prakashan.

B.Sc. Honours THEORETICAL MARKS Distribution		
Discipline Core (DC-1 to DC-14)	**Marks per question**	**Total**
Short Answer types (Answer five out of seven questions)	01	1x5=05
Long Answer types (Answer four out of seven questions)	03	3x4=12
Descriptive Answer types (Answer one out of two questions)	08	8x1=08
Full marks	**-**	**25**
Generic Elective (GE-1 to GE-4)	**Marks per question**	**Total**
Short Answer types (Answer five out of seven questions)	01	1x5=05
Long Answer types (Answer four out of seven questions)	03	3x4=12
Descriptive Answer types (Answer one out of two questions)	08	8x1=08
Full marks	**-**	**25**
Discipline Specific Elective (DSE 1, 2 and 3)	**Marks per question**	**Total**
Short Answer types (Answer five out of seven questions)	01	1x5=05
Long Answer types (Answer four out of seven questions)	03	3x4=12
Descriptive Answer types (Answer one out of two questions)	08	8x1=08
Full marks	**-**	**25**
Skill Enhancement Courses (SEC)	**Marks per question**	**Total**
Short Answer types (Answer five out of seven questions)	02	2x5=10
Long Answer types (Answer four out of seven questions)	05	5x4=20
Descriptive Answer types (Answer one out of two questions)	10	10x1=10
Full marks	**-**	**40**

Distribution of marks for B.Sc. Honours in Botany : Internal Assessment			
COURSE	**Internal Assessment**		**Total Marks**
DC/DSE/GE/SE	**Attendance (4)**	**Cont. Evaluation (6)** •Laboratory Note books •Field Diaries •Submissions (if Any) •Excursion diary/ report with photographs)	10

Discipline Core (DC)						
Distribution of marks for DC 1 : Paper 2 (Practical)						
	Topic	**Mark Distribution**				**Full Marks**
DC 1	**Algae and Microbiology (Alternatively)** Any one of the following: 1. Work out through preparation of semi-permanent slides (stained with cotton blue) and camera lucida drawing with proper measurement and magnification of reproductive structures 2. Microscopic examination of bacteriods by simple staining of root nodule (Methylene blue stain); Gram staining; Endospore staining with malachite green. (*Bacillus* spp.).	**Drawing and labelling**	**Measurement**	**Comment**	**Total**	**15**
		03	02	03	08	
		Slide Preparation & Fixing	**Drawing and labelling**	**Comment**	**Total**	
		03	02	03	08	
	Identifications : Any two from the following groups: 1. Thallus type or reproductive structure. 2. Types of Bacteria to be observed from permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation. 3. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.				02x02 =04	
	Viva				03	

Distribution of marks for DC 2 : Paper 4 (Practical)						
	Topic	**Mark Distribution**				**Full Marks**
DC 2	**Fungi, Lichen and Plant Pathology: (Alternatively)** Any one of the following: 1. Work out any one fungi with microscopic measurements of reproductive structures as per syllabus 2. Work out on histopathology of any one disease as per syllabus	**Drawing and labelling**	**Measurement**	**Comment**	**Total**	**15**
		03	02	03	08	
		Slide Preparation	**Drawing and labelling**	**Comment**	**Total**	
		02	03	03	08	
	Identifications : Any two from the following groups: 1. Morphological types of lichen (any one). 2. Identification with reasons of any one microscopic or macroscopic fungus as per syllabus. 3. Plant Pathological herbarium sheets (any one) as per syllabus				02 x 02 = 04	
	Viva				03	

Distribution of marks for DC 3 : Paper 6 (Practical)						
	Topic	**Mark Distribution**				**Full Marks**
	Archegoniate and Paleobotany: Work out for vegetative and /reproductive structures of bryophytes/ pteridophytes/ gymnosperms	**Section and Slide Preparation**	**Drawing and labelling**	**Comment**	**Total**	
DC 3		02	03	03	08	**15**
	Identifications Any two from the following groups: 1. Morphological and anatomical structures of bryophytes/ pteridophytes/ gymnosperms 2. Identification with reasons of any one microscopic and / or any one macroscopic **paleobotanical** specimens as per syllabus.				2 x 2 = 04	
	Viva				03	

Distribution of marks for DC 4 : Paper 8 (Practical)						
	Topic	**Mark Distribution**				**Full Marks**
	Morphology and Anatomy of Angiosperms Any one of the following: 1. T. S. of stem or root of any one as mentioned in the practical syllabus, staining by aqueous saffranin, draw, label and comment	**Slide Preparation**	**Drawing and labelling**	**Comment**	**Total**	
DC 4		02	03	03	08	**15**
	Identifications : **Any two** from the following groups: 1. Morphological identification: Different types of phyllotaxy in plants; Types of special inflorescence; Aestivations, Anther types and Placentation; Different types of fruits. 2. Anatomical identification of any one from the following: types of stomata, sclerides, raphides, lithocysts, aleurone grains, laticiferous ducts. 3. Identification from permanent slides/Micrographs/Photographs (As per practical syllabus.) 4. Identification of Adaptive Anatomy: a. Hydrophyte: *Eichhornia*, *Hydrilla* and *Ludwigia adscandens*. b. Xerophyte: *Nerium* and *Casuarina*				02x02 =04	
	Viva				03	

Distribution of marks for DC 5: Paper 10 (Practical)							
	Topic	**Mark Distribution**					**Full Marks**
DC 5	**Plant Systematics:** Taxonomical work out of a member belonging to the families mentioned in the practical syllabus	**Description (Diagnostic features)**	**Drawing and labelling**	**Floral formula and diagram**	**Identification Up to Genus using "Bengal Plants"**	**Total**	
		02	03	01+01=02	02	09	**15**
	Identifications: Spot identification of botanical names and families of two angiosperm plants as per theoretical syllabus (one from monocot and one from dicot).					1.5 x 02 = 03	
	Viva					03	

	Distribution of marks for DC 6 : Paper 12 (Practical)						
	Topic	**Mark Distribution**					**Full Marks**
DC 6	**Plant Ecology and Phytogeography**	**Principle**	**Requirements**	**Result and Calculation**	**Comment with reasons**	**Total**	
	Ecological and phytogeographical analysis as per practical syllabus.*(One from Ecology and one from Phytogeography: Alternatively)*	02	01	04	03	08	**15**
	Identifications: Ecological adaptations of any two specimens as mentioned in the practical syllabus.					2 x 2 = 04	
	Viva					03	

Distribution of marks for DC 7 : Paper 14 (Practical)					
	Topic	**Mark Distribution**			**Full Marks**
DC 7	**Economic botany:** 1. Micro-chemical tests: Qualitative determination of Ca, Mg, Fe and S.	**Experiment**	**Comment**	**Total**	
		04	02	06	**15**
	2. Detection of fibre/oils/cellulose	**Experiment**	**Comment**	**Total**	
		02	02	04	
	Identifications: As per practical syllabus.			02	
	Viva			03	

<table>
<tr><th colspan="7">Distribution of marks for DC 8 : Paper 16 (Practical)</th></tr>
<tr><td rowspan="6">DC 8</td><td>Topic</td><td colspan="4">Mark Distribution</td><td rowspan="2">Full Marks</td></tr>
<tr><td>Cell biology (Alternatively)

1. Free hand drawing, determination of 2n number and comment on chromosome morphology of metaphase chromosome of the supplied sample.</td><td>Slide Preparation</td><td>Drawing and labelling</td><td>Comment</td><td>Total</td></tr>
<tr><td rowspan="3">2. Determine mitotic index</td><td>02</td><td>04</td><td>02</td><td>08</td><td rowspan="4">15</td></tr>
<tr><td>Slide Preparation</td><td>Observation and calculation</td><td>Comment</td><td>Total</td></tr>
<tr><td>02</td><td>04</td><td>02</td><td>08</td></tr>
<tr><td rowspan="2">Plant Breeding

Demonstration : Emasculation of flower</td><td colspan="2">Requirements</td><td colspan="2">Demonstration</td><td rowspan="2">04</td></tr>
<tr><td colspan="2">01</td><td colspan="2">03</td></tr>
<tr><td colspan="5">Viva</td><td>03</td></tr>
</table>

<table>
<tr><th colspan="6">Distribution of marks for DC 9 : Paper 18 (Practical)</th></tr>
<tr><td rowspan="5">DC 9</td><td>Topic</td><td colspan="3">Mark Distribution</td><td>Full Marks</td></tr>
<tr><td rowspan="3">Genetics
1. Smear preparation of meiotic cells, identification of any one stage and its free hand drawing from the flower bud of Allium cepa

Biostatistics (Alternatively)

2. Determinations of goodness of fit in normal and modified mono and dihybrid ratios by Chi-square analysis and comment.
3. Univariate analysis of statistical data from statistical tables: calculation of mean, mode, median, standard deviation, and standard error (using seedling population / leaflet size).</td><td>Drawing and labelling</td><td>Comment</td><td>Total</td><td rowspan="4">15</td></tr>
<tr><td>03</td><td>02</td><td>05</td></tr>
<tr><td>Calculation</td><td>Comment</td><td></td></tr>
<tr><td>03</td><td>02</td><td>05</td></tr>
<tr><td colspan="4">Identifications : Meiosis – (i) normal stages (ii) abnormal stages – laggard, anaphase bridge, ring chromosome (Rhoeo discolor)</td><td>02</td></tr>
<tr><td colspan="4">Viva</td><td>03</td></tr>
</table>

<table>
<tr><th colspan="6">Distribution of marks for DC 10 : Paper 20 (Practical)</th></tr>
<tr><td rowspan="5">DC 10</td><td>Topic</td><td colspan="3">Mark Distribution</td><td>Full Marks</td></tr>
<tr><td rowspan="2">Reproductive Biology of Angiosperms:

1. Work out of pollen germination: Calculation of percentage germination in by using hanging drop method.

2. Dissection of developing seeds for endosperm with free-nuclear haustoria</td><td>Principle</td><td>Observation</td><td>Comment</td><td>Total</td><td rowspan="4">15</td></tr>
<tr><td>02</td><td>02</td><td>02</td><td>06</td></tr>
<tr><td>Slide preparation and drawing</td><td colspan="2">Comment</td><td>Total</td></tr>
<tr><td>02</td><td colspan="2">02</td><td>04</td></tr>
<tr><td colspan="4">Identifications: As per practical syllabus.</td><td>02</td></tr>
<tr><td colspan="4">Viva</td><td>03</td></tr>
</table>

<table>
<tr><th colspan="7">Distribution of marks for DC 11 : Paper 22 (Practical)</th></tr>
<tr><td rowspan="3">DC 11</td><td>Topic</td><td colspan="5">Mark Distribution</td><td>Full Marks</td></tr>
<tr><td>Plant Physiology:

1. One physiological experiment as per practical syllabus.</td><td>Requisition</td><td>Principle</td><td>Result and Calculation</td><td>Comment</td><td>Total</td><td rowspan="2">15</td></tr>
<tr><td>02</td><td>02</td><td>05</td><td>03</td><td>12</td></tr>
<tr><td colspan="5">Viva</td><td>03</td></tr>
<tr><th colspan="7">Distribution of marks for DC 12 : Paper 24 (Practical)</th></tr>
<tr><td rowspan="3">DC 12</td><td>Topic</td><td colspan="5">Mark Distribution</td><td>Full Marks</td></tr>
<tr><td>Plant Metabolism:

1. One experiment as per practical syllabus.</td><td>Requisition</td><td>Principle</td><td>Result and Calculation</td><td>Comment</td><td>Total</td><td rowspan="2">15</td></tr>
<tr><td>02</td><td>02</td><td>05</td><td>03</td><td>12</td></tr>
<tr><td colspan="5">Viva</td><td>03</td></tr>
</table>

Distribution of marks for DC 13 : Paper 26 (Practical)							
	Topic	**Mark Distribution**					**Full Marks**
	Biomolecules (Biochemistry): Any one of the following: 1. One qualitative biochemical experiment as per syllabus. 2. One quantitative biochemical estimation as per syllabus.	**Requisition**	**Procedure**	**Observation**	**Comment**	**Total**	
DC 13		02	05	03	02	= 12	**15**
	Viva					= 03	

Distribution of marks for DC 14 : Paper 28 (Practical)							
	Topic	**Mark Distribution**					**Full Marks**
	Plant Biotechnology:	**Requisition**	**Principle**	**Result and Calculation**	**Comment**	**Total**	
DC 14	One experiment / demonstration as per practical syllabus.	02	02	05	03	12	**15**
	Viva					03	

Discipline Specific Elective (DSE 1, 2 and 3)(Practical)			
Distribution of marks for all DSE (Practical)			
Analysis/ Demonstration	**Submission**	**Viva-voce**	**Full Marks**
10	02	03	**15**
Discipline Specific Elective (DSE- 4) (Project as per the syllabus)			
Dissertation copy	Presentation	Viva	**Full marks**
25	15	10	**50**

Generic Elective (GE) (Practical)						
Biodiversity (Microbes, Algae, Fungi and Archegoniate)						
GE- 1	**Work out with Drawing & labelling (Algae/Fungi)**	**Work out with Drawing & labelling (Microbiology/Pteridophyte/ Bryophyte)**		**Identification (Gymnology/ Lichens)**	**Viva-voce**	**Full Marks**
	04	04		02	03	**15**
Plant Ecology and Taxonomy						
GE- 2	**Taxonomic workout : Drawing and labelling Floral formula and diagram + Identification**			**Ecological Experiments (Any one)**	**Viva - voce**	**Full Marks**
	02+02+02=06			04	03	**15**
Plant Anatomy and Embryology						
GE- 3	**Anatomical workout (Semi permanent mounts as per the practical syllabus)**	**Embryology (Dissection of embryo/ endosperm from developing seeds)**		**Identification (Gymnology/Lichens)**	**Viva - voce**	**Full Marks**
	06	04		02	03	**15**
Plant Physiology and Metabolism						
GE- 4	**Requisition**	**Principle**	**Result and Calculation**	**Comment**	**Total**	**Viva - voce**	**Full Marks**
	02	02	05	03	12	03	**15**
Economic Botany and Plant Biotechnology						
	Economic Botany		**Plant Biotechnology**		**Identification**	**Viva - voce**	**Full Marks**
	06		04		02	03	**15**

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