UNIVERSITY OF DELHI

DEPARTMENT OF BOTANY

4 YEAR UNDERGRADUATE PROGRAMME

(Courses effective from Academic Year 2013-14)

SYLLABUS OF COURSES TO BE OFFERED

Disciplinary Courses I, Disciplinary Courses II

& Applied Courses

Note: The courses are uploaded as sent by the Department concerned. The scheme of marks will be determined by the University and will be corrected in the syllabus accordingly. Editing, typographical changes and formatting will be undertaken further.

4 Year Undergraduate Programme Secretariat
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Preamble

Over the years, plant science (Botany) has shown enormous gain in information and applications owing to tremendous input from research in all its aspects. With global recognition of the need for conservation, field plant biologists have contributed significantly on plant diversity. Taxonomists have explored newer dimensions for the classification of plants. New insights have been gained in functional and structural aspects of plant development by utilizing novel tools and techniques for botanical research. Challenging areas of teaching and research have emerged in ecology and reproductive biology, with impact being felt on pollution and climate change. Today plant science is a fusion of the traditional components with the modern aspects of biochemistry, molecular biology and biotechnology. Keeping these advancements in view, a revision of the curriculum at the undergraduate level is perfectly timed. From the beginning of 2013-14 session, the Botany students of Delhi University shall have the benefit of a balanced, carefully-crafted course structure taking care of different aspects of plant science, namely plant diversity, physiology, biochemistry, molecular biology, reproduction, anatomy, taxonomy, ecology, economic botany and the impact of environment on the growth and development of plants. All these aspects have been given due weightage over the eight semesters. A paper on Functional Plant Biology takes care of the stress physiology and recent aspects of genomics. It is essential for the undergraduate students to acquaint themselves with various tools and techniques for exploring the world of plants up to the subcellular level. A paper on this aspect is proposed to provide such an opportunity to the students before they engage themselves with the learning of research methodologies. Keeping the employment entrepreneurship in mind, four new applied courses have been introduced. These are: Industrial and Environmental Microbiology, Plant Breeding and Crop Improvement, Natural Resource Management and Horticultural Practices and

Post-Harvest Technology. These courses shall provide the botany students hands on experience and professional inputs. On the whole, the curriculum is a source of lot of information and is supported by rich resource materials. It is hoped that a student graduating in Botany from Delhi University with the new curriculum will be a complete botanist at Honours level.

COURSE STRUCTURE – BOTANY (Final Version)

4 Year Undergraduate Programme (w.e.f. July 2013)

	DC-I	DC-II	AC
Sem. I -	1. Phycology and Microbiology 2. Plant Cell Biology		
Sem. II -	3. Mycology and Phytopathology 4. Fundamentals of Biochemistry		
Sem. III -	5. Archegoniates 6. Morphology and Anatomy of Angiosperms	1.Biodiversity-1 (Microbes, Algae and Fungi)	1.Industrial and Environmental Microbiology
Sem. IV -	7. Plant Systematics 8. Concepts of Genetics	2.Biodiversity-2 (Archegoniates)	2.Plant Breeding & Crop Improvement
Sem. V -	9. Ecology and Phytogeography 10. Plant Resource Utilization 11. Fundamentals of Molecular Biology	3.Economic Botany and Plant Biotechnology	3.Natural Resource Management
Sem. VI -	12. Reproductive Biology of Angiosperms 13. Plant Physiology 14. Analytical Techniques in Plant Science	4.Plant Ecology and Taxonomy	4.Horticultural Practices and Post-Harvest Technology
Sem. VII -	15. Plant Metabolism 16. Advanced Cell and Molecular Biology 17. Research Methodology	5.Plant Anatomy and Embryology	
Sem. VIII -	18. Plant Biotechnology 19. Functional Plant Biology 20. Dissertation	6.Plant Physiology and Metabolism	

DISCIPLINE COURSE I

(Semester I)

Paper 1: PHYCOLOGY AND MICROBIOLOGY

THEORY

Unit 1: Diversity of life

Classification; Evolution: basic concepts of Darwin's theory, Neo-Darwinism. **(2 lectures)**

Unit 2: Viruses

Discovery, classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (Tphage), lytic and lysogenic cycle; RNA virus (TMV) **(7 lectures)**

Unit 3: Bacteria

Discovery, general characteristics, types-archaebacteria, eubacteria, planctomycetes, wall-less forms (mycoplasma and spheroplasts), cell structure, nutritional types, reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). **(8 lectures)**

Unit 4: Applied Microbiology

Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine). **(3 lectures)**

Unit 5: Algae

General characteristics, ecology and distribution, classification of algae. **(3 lectures)**

Unit 6: Cyanophyta

Occurrence, range of thallus organization, cell structure, heterocyst, eproduction. Morphology and life-cycle of *Nostoc.* **(4 lectures)**

Unit 7: Chlorophyta

Occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Chlamydomonos* and *Oedogonium.* **(4 lectures)**

Unit 8: Charophyta and Xanthophyta

Occurrence, morphology, cell structure and life-cycle of *Chara*. Evolutionary significance.
Occurrence, morphology and life-cycle of *Vaucheria* **(4 lectures)**

Unit 9: Phaeophyta

Occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Ectocarpus* and *Fucus.* **(5 lectures)**

Unit 10: Rhodophyta

Occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia.* **(4 lectures)**

Unit 11: Applied Phycology

Role of algae in the environment, biotechnology and industry **(4 lectures)**

PRACTICALS

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

Phycology

Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), *Oedogonium, Chara, Vaucheria, Ectocarpus, Fucus* and Polysiphonia* through temporary preparations and permanent slides.

(* *Fucus* - Specimen and permanent slides)

ESSENTIAL READINGS

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.

DISCIPLINE COURSE I

(Semester I)

Paper 2: PLANT CELL BIOLOGY

THEORY

Unit1: The cell

Cell as a unit of structure and function: a historical perspective; Characteristics of prokaryotic and eukaryotic cells; Diversity in cell size, phages, viroids, mycoplasma, and prions. Origin of eukaryotic cell (Endosymbiotic theory). **(4 lectures)**

Unit 2: Cell wall

Chemistry, structure and function of Plant Cell Wall. **(2 lectures)**

Unit 3: Plasma membrane

Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, a brief account of endocytosis and exocytosis. **(8 lectures)**

Unit 4: Nucleus

Structure-nuclear envelope, nuclear pore complex, nuclear lamina, types of chromatins; Packaging of DNA; Nucleolus – structure and role in the biogenesis of ribosomes. **(7 lectures)**

Unit 5: Chloroplast and mitochondria

Structure and functions (no pathways); Semi-autonomous nature. **(5 lectures)**

Unit 6: Endomembrane system

Structure, types and function of ER; Structure and function of Golgi apparatus; Morphology, types and functions of lysosomes; Plant cell vacuoles. **(10 lectures)**

Unit 7: Microbodies

Structure and functions of peroxisomes, glyoxysomes and microbodies. **(2 lectures)**

Unit 8: Cytoskeleton

Role and structure of microtubules, microfilaments and intermediary filaments. Structure and functions of flagella and Cilia. **(5 lectures)**

Unit 9: Cell division

Cell cycle, mitosis, meiosis and cytokinesis. **(5 lectures)**

PRACTICALS

1. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo/Crinum*.
2. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
3. Measurement of cell size by the technique of micrometry.
4. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
5. Study of cell and its organelles with the help of electron micrographs.
6. Cytochemical staining of cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
7. To study the phenomenon of plasmolysis and deplasmolysis using five different concentrations of sucrose.
8. To study the effect of organic solvent on membrane permeability.
9. To study the effect of temperature on membrane permeability.
10. To study mitosis in onion root tips using temporary mounts.

ESSENTIAL READINGS

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.

DISCIPLINE COURSE I

(Semester II)

Paper 3: MYCOLOGY AND PHYTOPATHOLOGY

THEORY

Unit 1: Introduction to true fungi

Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition and nutrition; Classification **(6 lectures)**

Unit 2: Chytridiomycetes

General account **(1 lecture)**

Unit 3: Zygomycota

General characteristics; Ecology; Thallus organisation; Life cycle with reference to *Rhizopus*. **(3 lectures)**

Unit 4: Ascomycota

General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces, Aspergillus*, *Penicillium, Alternaria* and *Neurospora peziza.* **(11 lectures)**

Unit 5: Basidiomycota

General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation. **(8 lectures)**

Unit 6: Allied Fungi

General characterises; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies. **(3 lectures)**

Unit 7: Oomycota

General characteristic; Ecology; Life cycle and classification with reference to *Albugo.* **(4 lectures)**

Unit 8: Symbiotic associations

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance. **(4 lectures)**

Unit 9: Phytopathology

Terms and concepts; General symptoms; Prevention and control of plant diseases. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, white rust of crucifers. **(8 lectures)**

PRACTICALS

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria:* Specimens/photographs and temporary mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs)
11. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

ESSENTIAL READINGS

1. Alexopoulos, C.J., Nims, 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. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

DISCIPLINE COURSE I

(Semester II)

Paper 4: FUNDAMENTALS OF PLANT BIOCHEMISTRY

THEORY

Unit 1: Introduction to cell chemistry

Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **(3 lectures)**

Unit 2: Carbohydrates

Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin); Isomers and derivatives of glucose, glucosamine and gluconic acid. **(8 lectures)**

Unit 3: Lipids

Types and their biological roles; Fatty acids: Nomenclature and classification (omega fatty acids and trans fats); Structure of phosphatidic acid; Types of phospholipids; Types of glycolipids, sulpholipids, waxes and sterols. **(4 lectures)**

Unit 4: Amino acids and proteins

Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quarternary; Isoelectric point; Protein denaturation and biological roles of proteins. **(6 lectures)**

Unit 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. **(8 lectures)**

Unit 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. **(6 lectures)**

Unit 7: Enzymes

Nomenclature and classification; Concept of holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; 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. **(9 lectures)**

Unit 8: Plant specific organic molecules

Examples and roles of alkaloids, terpenes and phenolics (no structural formulae) **(4 lectures)**

PRACTICALS

1. Preparation of buffers and demonstration of their buffering activity.
2. Microchemical tests for glucose (Fehlings test) fructose (Seliwanoff test), sucrose, starch (Potassium iodide text), proteins (Millons/Xanthoproteic/Ninhydrin/Biuret test) and oil (Sudan III).
3. Determining the isoelectric point of milk protein using a range of pH.
4. Demonstration on the activity of catalase and study the effect of pH (any five pHs).
5. Demonstration of the activity of urease and study the effect of substrate concentration.
6. Demonstration of the activity of invertase and study the effect of heavy metals.
7. To study the effect of enzyme concentration on enzyme urease activity.
8. To test for presence of ascorbic acid in different plant juices.

ESSENTIAL READINGS

1. Ochs, R.S. (2014). Biochemistry, Johns & Bartlett Learning, USA.
2. Bowsher, C., Steer, M., Tobin, A. (2008). Plant Biochemistry. Garland Science, Taylor & Francis Group, U.K.
3. Plummer, D.T. (1996). An introduction to Practical Biochemistry. Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi. 3rd edition.
4. Bajracharya D. (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

DISCIPLINE COURSE I

(Semester III)

Paper 5: ARCHEGONIATES

THEORY

Unit 1: Introduction

Unifying features of archegoniates; Transition to land habit; Alternation of generations.

(1 lecture)

Unit 2: 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). Morphology of *Riccia*, *Porella* and *Sphagnum*. Ecological and economic importance of bryophytes with special reference to *Sphagnum*. **(15 lecture)**

Unit 3: Pteridophytes

General characteristics, classification, early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Apogamy, and apospory, heterospory and seed habit, telome theory, stelar evolution. Ecological and economical importance.

(17 lectures)

Unit 4: Gymnosperms

General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum*. (Developmental details not to be included). Ecological and economical importance. **(15 lectures)**

PRACTICALS

1. ***Riccia*** – Morphology of thallus.
2. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. ***Porella***- Morphology only.
5. ***Sphagnum***- Morphology of plant, whole mount of leaf (permanent slide only).

6. ***Funaria***- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. ***Psilotum***- Study of specimen, transverse section of synangium (permanent slide).
8. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
9. ***Equisetum***- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. ***Pteris***- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
11. ***Cycas***- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
12. ***Pinus***- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section &radial longitudinal sections stem (permanent slide).
13. ***Gnetum***- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)
14. **Botanical excursion.**

ESSENTIAL READINGS

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.

DISCIPLINE COURSE I

(Semester III)

Paper 6: MORPHOLOGY AND ANATOMY OF ANGIOSPERMS

THEORY

Unit 1: Plant Morphology

Morphology of root, stem and leaf. **(2 Periods)**

Unit 2: Tissues

Classification of tissues; Simple and complex tissues (no phylogeny); Pits and plasmodesmata; Wall ingrowths and transfer cells, Ergastic substances. **(11 Periods)**

Unit 3: Stem

Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. **(5 Periods)**

Unit 4: Leaf

Structure of dicot and monocot leaf, Kranz anatomy. **(3 Periods)**

Unit 5: Root

Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root. **(5 Periods)**

Unit 6: Vascular Cambium

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. **(6 Periods)**

Unit 7: Wood

Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. **(5 Periods)**

Unit 8: Periderm

Development and composition of periderm, rhytidome and lenticels. **(2 Periods)**

Unit 9: Adaptive and Protective Systems

Epidermal tissue system, cuticle, epicuticular waxes, trichomes(uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes. **(7 Periods)**

Unit 10: Secretory System

Hydathodes, cavities, lithocysts and laticifers. **(2 periods)**

PRACTICALS

Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
6. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
7. Root: monocot, dicot, secondary growth.
8. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
9. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
10. Adaptive Anatomy: xerophytes, hydrophytes.
11. Secretory tissues: cavities, lithocysts and laticifers.

ESSENTIAL READINGS

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.

DISCIPLINE COURSE I

(Semester IV)

Paper 7: PLANT SYSTEMATICS

THEORY

Unit 1: Plant identification, Classification, Nomenclature; Biosystematics. (2 lectures)

Unit 2: Identification

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 **(6 lectures)**

Unit 3: Systematics- an interdisciplinary science

Evidence from palynology, cytology, phytochemistry and molecular data. **(8 lectures)**

Unit 4: Taxonomic hierarchy

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary). **(5 lectures)**

Unit 5: 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. **(9 lectures)**

Unit 6: Systems of classification

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification. **(8 lectures)**

Unit 7: Biometrics, numerical taxonomy and cladistics

Characters; Variations; OTUs, character weighting and coding; cluster analysis; Phenograms, cladograms (definitions and differences). **(5 lectures)**

Unit 8: Phylogeny of Angiosperms

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly and polyphyly. **(5 lectures)**

PRACTICALS

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*
Myrtaceae	-	*Eucalyptus, Callistemon*
Umbelliferae	-	*Coriandrum /Anethum / Foeniculum*
Asteraceae	-	*Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax*
Solanaceae	-	*Solanum nigrum/Withania*
Lamiaceae	-	*Salvia/Ocimum*
Euphorbiaceae	-	*Euphorbia hirta/E.milii, Jatropha*
Liliaceae	-	*Asphodelus/Lilium/Allium*
Poaceae	-	*Triticum/Hordeum/Avena*

2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

ESSENTIAL READINGS

1. Singh, (2012). *Plant Systematics:* Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). An Introduction to *Plant Taxonomy.* Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). *Flora* of Delhi. CSIR, New Delhi.
5. Radford, A.E. (1986). Fundamentals of *Plant Systematics*. Harper and Row, New York.

DISCIPLINE COURSE I

(Semester IV)

Paper 8: CONCEPTS OF GENETICS

THEORY

Unit 1: Mendelian genetics and its extension

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance. **(16 lectures)**

Unit 2: Extrachromosomal Inheritance

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium.*

(4 lectures)

Unit 3: 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. (**10 lectures)**

Unit 4: Variation in chromosome number and structure

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

(8 lectures)

Unit 5: Gene mutations

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. **(6 lectures)**

Unit 6: Fine structure of gene

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T_4, rII Locus. **(4 lectures)**

PRACTICALS

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios.
3. Pedigree analysis for dominant and recessive autosomal and sex linked traits.

4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Blood Typing: ABO groups & Rh factor.
6. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs.
7. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
8. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

ESSENTIAL READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

DISCIPLINE COURSE I

(Semester V)

Paper 9: ECOLOGY AND PHYTOGEOGRAPHY

THEORY

Unit 1: Introduction
Basic concepts; Levels of organization. **(1 lecture)**

Unit 2: Soil
Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development. **(7 lectures)**

Unit 3: Water
Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.
(2 lectures)

Unit 4: Light, temperature, wind and fire
Variations; adaptations of plants to their variation. **(4 lectures)**

Unit 5: Biotic interactions **(2 lectures)**

Unit 6: Population ecology
Characteristics and Dynamics. **(4 lectures)**

Unit 7: Plant communities
Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.
(7 lectures)

Unit 8: Ecosystems
Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.
(5 lectures)

Unit 9: Functional aspects of ecosystem
Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus. **(8 lectures)**

Unit 10: Phytogeography
Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Vegetation of Delhi **(8 lectures)**

PRACTICALS

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
   (b). Study of biotic interactions of the following:
   Stem parasite (*Cuscuta*)
   Root parasite (*Orobanche*)
   Epiphytes
   Predation (Insectivorous plants)
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarise students with ecology of different sites.

ESSENTIAL READINGS

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

DISCIPLINE COURSE I

(Semester V)

Paper 10: PLANT RESOURCE UTILIZATION

THEORY

Unit 1: Origin of Cultivated Plants
Concept of Centres of Origin, their importance with reference to Vavilov's work.
(2 lectures)

Unit 2: Cereals
Wheat and Rice (origin, morphology, processing & uses), brief account of millets.
(5 lectures)

Unit 3: Legumes
General account, importance to man and ecosystem **(2 lectures)**

Unit 4: Sugars & Starches
Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses. **(4 lectures)**

Unit 5: Spices
Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper **(5 lectures)**

Unit 6: Beverages
Tea, Coffee (morphology, processing & uses) **(4 lectures)**

Unit 7: Oils & Fats
General description, classification, extraction, their uses and health implications, *Brassica* and Coconut (Botanical name, family & uses) **(6 lectures)**

Unit 8: Essential Oils
General account, extraction methods, comparison with fatty oils & their uses.
(3 lectures)

Unit 9: Natural Rubber
Para-rubber: tapping, processing and uses. **(3 lectures)**

Unit 10: Drug-yielding plants
Therapeutic and habit-forming drugs with special reference to C*inchona, Digitalis, Papaver* and *Cannabis.* **(4 lectures)**

Unit 11: Tobacco

Tobacco (Morphology, processing, uses and health hazards) **(4 lectures)**

Unit 12: Fibres

Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses) **(6 lectures)**

PRACTICALS

1. **Cereals**: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legumes**: Soya bean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. **Sugars & Starches**: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. **Spices:** Black pepper, Fennel and Clove (habit and sections).
5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Oils & Fats**: Coconut- T.S. nut, Mustard – plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants**: Habit sketch of *Rosa*, V*etiveria, Santalum* and *Eucalyptus* (specimens/photographs).
8. **Rubber**: specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants**: Specimens of *Digitalis, Papaver* and *Cannabis.*
10. **Tobacco**: specimen and products of Tobacco.
11. **Fibre-yielding plants**: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fibre and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fibre).

ESSENTIAL 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.

DISCIPLINE COURSE I

(Semester V)

Paper 11: FUNDAMENTALS OF MOLECULAR BIOLOGY

THEORY

Unit 1: Nucleic acids : Carriers of genetic information

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment); Organization of DNA in bacteria and viruses (TMV, T4 bacteriophage) **(6 lectures)**

Unit 2:The replication of DNA

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

(10 lectures)

Unit 3: Central dogma and genetic code

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features**)** **(5 lectures)**

Unit 4: Mechanism of Transcription

Transcription in prokaryotes; Transcription in eukaryotes **(15 lectures)**

Unit 5: Processing and modification of RNA

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.

(12 lectures)

PRACTICALS

1. DNA isolation from cauliflower head.
2. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
3. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
4. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

ESSENTIAL READINGS

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

DISCIPLINE COURSE I

(Semester VI)

Paper 12: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

THEORY

Unit 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 lectures)**

Unit 2: Anther

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. **(4 lectures)**

Unit 3: Pollen biology

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. **(6 lectures)**

Unit 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. **(6 lectures)**

Unit 5: Pollination and fertilization

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. **(6 lectures)**

Unit 6: Self incompatibility

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization. **(6 lectures)**

Unit 7: Endosperm

Types, development, structure and functions. **(4 lectures)**

Unit 8: Embryo

Six types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. **(4 lectures)**

Unit 9: Seed

Structure, importance and dispersal mechanisms **(3 lectures)**

Units 10: Polyembryony and apomixis

Introduction; Classification; Causes and applications. **(5 lectures)**

Unit 11: Germline transformation

Pollen grain and ovules through pollen tube pathway method/ *Agrobacterium*/ electrofusion/ floral dip/biolistic. **(2 lectures)**

PRACTICALS

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: Tetrazolium test.
3. Pollen 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).
5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
6. Intra-ovarian pollination; Test tube pollination through photographs.
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.

ESSENTIAL READINGS

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

DISCIPLINE COURSE I

(Semester VI)

Paper 13: PLANT PHYSIOLOGY

THEORY

Unit 1: Plant water relationship

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. **(8 lectures)**

Unit 2: Mineral nutrition

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents. **(6 lectures)**

Unit 3: 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. **(6 lectures)**

Unit 4: 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. **(6 lectures)**

Unit 5: Plant growth regulators

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene. Brassinosteroids and Jasmonic acid.

(14 lectures)

Unit 6: Physiology of flowering

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

(4 lectures)

Unit 7: Phytochrome

Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action. **(4 lectures)**

PRACTICALS

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

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

ESSENTIAL READINGS

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L. and Zeiger, E. (2006). Plant Physiology. Sinauer Associates Inc. USA. 5th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

DISCIPLINE COURSE I

(Semester VI)

Paper 14: Analytical Techniques in Plant Sciences

THEORY

Unit 1: Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching. **(12 lectures)**

Unit 2: Cell fractionation

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes. **(6 lectures)**

Unit 3: Radioisotopes

Use in biological research, auto-radiography, pulse chase experiment. **(3 lectures)**

Unit 4: Spectrophotometry

Principle and its application in biological research. **(3 lectures)**

Unit 5: Chromatography

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography. **(6 lectures)**

Unit 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 **(5 lectures)**

Unit 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. **(13 lectures)**

PRACTICALS

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).

ESSENTIAL 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 COURSE I

(Semester VII)

Paper 15: PLANT METABOLISM

THEORY

Unit 1: Concept of metabolism

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric ,covalent modulation and Isozymes). **(4 lectures)**

Unit 2: Carbon assimilation

Historical background, photosynthetic pigments, 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, C_4 pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction. **(13 lectures)**

Unit 3: Carbohydrate metabolism

Synthesis and catabolism of sucrose and starch. **(2 lectures)**

Unit 4: Carbon Oxidation

Glycolysis, fate of pyruvate, regulation of glycolysis, 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.

(10 lectures)

Unit 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. **(5 lectures)**

Unit 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. **(6 lectures)**

Unit 7: Nitrogen metabolism

Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

(6 lectures)

Unit 8: Integration of metabolic pathways

Interrelations of carbohydrate, lipid and protein metabolism. **(2 lectures)**

PRACTICALS

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate Reductase in germinationg leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

ESSENTIAL READINGS

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L. and Zeiger, E. (2006). Plant Physiology. Sinauer Associates Inc. USA. 5th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

DISCIPLINE COURSE I

(Semester VII)

Paper 16: ADVANCED CELL AND MOLECULAR BIOLOGY

THEORY

Unit 1: Protein trafficking in cell. **(6 lectures)**

Unit 2: Transport of molecules between the nucleus and the cytosol. **(2 lectures)**

Unit 3: Receptor mediated transport (endocytosis). **(2 lectures)**

Unit 4: Cell signaling

Signal transduction mechanisms in plants: An overview of signaling molecules; Nitric oxide an intracellular signaling molecule; Receptors for signaling molecules in plants; Protein degradation in plant signaling pathways; Integrated signal transduction, phytochrome signaling pathways. **(6 lectures)**

Unit 5: Molecular motors and their role.

Kinesin, dyneins, myosins **(3 lectures)**

Unit 6: Regulation of cell cycle **(3 lectures)**

Unit 7: DNA repair mechanisms

Photoreactivation; Repair in dark **(2 lectures)**

Unit 8: Regulation of transcription in prokaryotes and eukaryotes

Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing. **(8 lectures)**

Unit 9: Translation (Prokaryotes and eukaryotes)

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins. **(10 lectures)**

Unit 10: Regulatory RNAs

Riboswitches, RNA interference, miRNA, RNAi, Regulatory RNA in dosage compensation (mechanism of X-inactivation). **(6 lectures)**

PRACTICALS

1. Preparation of cheek cell smears to observe Barr bodies.
2. Preparation of LB medium and raising *E.Coli.*
3. Study of antibiotic resistance in *E.Coli.*
4. Isolation of genomic DNA from *E.Coli.*
5. Study of structure of transfer RNA : 2D and 3D through photographs.
6. Study of special chromosomes- Lampbrush and Salivary gland chromosome.
7. To calculate mitotic index and duration of stages in mitosis in temporary preparation of normal and colchicine hinted micrographs showing movement of proteins through endomembrane system.

ESSENTIAL READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics. John Wiley & Sons. Canada. 8th edition.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
3. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley & Sons Inc. U.S.A. 5th edition.
4. Karp, G. (2010). Cell Biology. John Wiley and sons, U.S.A. 6th edition.

DISCIPLINE COURSE I

(Semester VII)

Paper 17: RESEARCH METHODOLOGY

THEORY

Unit 1: Basic concepts of research

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs emperical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

(8 lectures)

Unit 2: General laboratory practices

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

(8 lectures)

Unit 3: Data collection and documentation of observations

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography. **(6 lectures)**

Unit 4: Overview of Biological Problems

History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network. **(6 lectures)**

Unit 5: **Methods to study plant cell/tissue structure**

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections. **(6 lectures)**

Unit 6: Plant microtechniques

Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials **(8 lectures)**

Unit 7: The art of scientific writing and its presentation

Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism. **(6 lectures)**

PRACTICALS

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.

ESSENTIAL READINGS

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

DISCIPLINE COURSE I

(Semester VIII)

Paper 18: PLANT BIOTECHNOLOGY

THEORY

Unit 1: Plant Tissue Culture

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation) **(12 lectures)**

Unit 2: 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 and briefly PAC, MAC, HAC).Gene Cloning (Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligo-nucleotide, heterologous, PCR; 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). **(25 lectures)**

Unit 3: Applications of Biotechnology

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns **(11 lectures)**

PRACTICALS

1. (a) Preparation of MS medium.
   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.

2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.

ESSENTIAL READINGS

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

DISCIPLINE COURSE I

(Semester VIII)

Paper 19: FUNCTIONAL PLANT BIOLOGY

THEORY

Unit 1: Response of plants to environmental stress

Water stress; High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis–related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates. **(10 lectures)**

Unit 2: 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. **(3 lectures)**

Unit 3: Reactive oxygen species–Production and scavenging mechanisms. **(2 lectures)**

Unit 4: Structural genomics

An overview; Correlated Genetic; Cytological, and physical maps of chromosomes; Molecular map; Map-position based cloning of gene: Chromosomes walking; Chromosomes jumping whole genome sequencing; The Human genome Project. **(6 lectures)**

Unit 5: Functional genomics

Transcriptome; Proteome and Interactome RNA and Protein assays of genome function; Expressed sequences; Array hybridization and gene chips to study transcriptome; Reverse genetics through random and targeted mutagenesis. **(4 lectures)**

Unit 6: Comparative genomics

Phylogenetic interference comparative genomics of mice and humans, Chimpanzees and humans; Chloroplast and Mitochondrial genomics; genome evolution in cereal grasses **(3 lectures)**

Unit 7: Model organisms and systems biology **(2 lectures)**

Unit 8: Introduction to bioinformatics

Definition, Branches**;** Biological Database: Definition and classification; NCBI: Introduction, tools, databases, database retrieval tool, sequence submission tools, BLAST (types) ; Nucleotide database**;** Protein database. **(6 lectures)**

Unit 9: Sequence alignment

Introduction, concept of alignment; Multiple sequence alignment; CLUSTALW (www.ebi.ac.uk/clustalw). **(6 lectures)**

Unit 10: Molecular phylogeny

Introduction; Representation of Phylogeny; Types of Trees; Methods of phylogeny.

(6 lectures)

PRACTICALS

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. Zymographic analysis of peroxidase.
4. Zymographic analysis of superoxide dismutase activity.
5. Comparative maps of cereal grasses.
6. Nucleic acid and protein databases.
7. Sequence retrieval from databases.
8. Sequence alignment.
9. Sequence homology and Gene annotation.
10. Construction of Phylogenetic tree

ESSENTIAL READINGS

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists. Rockville, Maryland. U.S.A.
2. Taiz, L. and Zeiger, E. (2006). Plant Physiology. Sinauer Associates Inc. USA. 5th Edition.
3. Ghosh, Z. and Bibekanand, M. (2008). Bioinformatics: Principles and Applications. Oxford University Press. Delhi.
4. Pevsner, J. (2009). Bioinformatics and Functional Genomics. Wiley-Blackwell. U.S.A. 2nd edition.
5. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.

DISCIPLINE COURSE I

(Semester VIII)

Paper 20: DISSERTATION

DISCIPLINE COURSE II

(Semester III)

DC-II- 1: Biodiversity-I (Microbes, Algae and Fungi)

THEORY

Unit 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; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance

(16 lectures)

Unit 2: Algae

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Chlamydomonas, Oedogonium*, *Vaucheria, Fucus, Polysiphonia*. Economic importance of algae

(16 lectures)

Unit 3: Fungi

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium, Alternaria* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance **(16 lectures)**

PRACTICALS

5. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
6. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
7. Gram staining
8. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), *Oedogonium, Vaucheria, Fucus* and Polysiphonia* through temporary preparations and permanent slides. (* *Fucus* - Specimen and permanent slides)
9. *Rhizopus and Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
10. *Alternaria:* Specimens/photographs and tease mounts.

11. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
12. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
13. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
14. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)

ESSENTIAL 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.

DISCIPLINE COURSE II

(Semester IV)

DC-II- 2: BIODIVERSITY – 2 (ARCHEGONIATES)

THEORY

Unit 1:Introduction

Unifying features of archegoniates, Transition to land habit, Alternation of generations.

(1 lecture)

Unit 2:Bryophytes

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*. **(15 lectures)**

Unit 3:Pteridophytes

General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes. **(17 lectures)**

Unit 4:Gymnosperms

General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus*. (Developmental details not to be included). Ecological and economical importance. **(15 lectures)**

PRACTICALS

1. ***Marchantia***- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
2. ***Funaria***- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
3. ***Selaginella***- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
4. ***Equisetum***- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).

5. ***Pteris***- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
6. ***Cycas***- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
7. ***Pinus***- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

ESSENTIAL READINGS

1. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
2. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
3. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
4. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

DISCIPLINE COURSE II

(Semester V)

DC-II- 3:ECONOMIC BOTANY AND PLANT BIOTECHNOLOGY

THEORY

Unit 1: Origin of Cultivated Plants
Concept of centres of origin, their importance with reference to Vavilov's work **(4 lectures)**

Unit 2: Cereals
Wheat -Origin, morphology, uses **(2 lectures)**

Unit 3: Legumes
General account with special reference to Gram and soybean **(4 lectures)**

Unit 4: Spices
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses) **(3 lectures)**

Unit 5: Beverages
Tea (morphology, processing, uses) **(3 lectures)**

Unit 6: Oils and Fats
General description with special reference to groundnut **(4 lectures)**

Unit 7: Fibre Yielding Plants
General description with special reference to Cotton (Botanical name, family, part used, morphology and uses) **(4 lectures)**

Unit 8: Introduction to biotechnology **(1 lecture)**

Unit 9: Plant tissue culture
Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo & endosperm culture with their applications **(8 lectures)**

Unit 10: Recombinant DNA Techniques
Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR.

Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Molecular diagnosis of human disease, Human gene Therapy. **(15 lectures)**

PRACTICALS

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

ESSENTIAL READINGS

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Chawla, H.S. (2002). Introduction to Plant Biotechnology, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 2nd edition.

DISCIPLINE COURSE II

(Semester VI)

DC-II- 4:PLANT ECOLOGY AND TAXONOMY

THEORY

Unit 1: Introduction **(1 lecture)**

Unit 2: 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 **(8 lectures)**

Unit 3: Plant communities

Characters; Ecotone and edge effect; Succession; Processes and types **(4 lectures)**

Unit 4: Ecosystem

Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and phosphorous **(7 lectures)**

Unit 5: Phytogeography

Principle biogeographical zones; Endemism **(4 lectures)**

Unit 6 Introduction to plant taxonomy

Identification, Classification, Nomenclature. **(1 lecture)**

Unit 7 Identification

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access **(3 lectures)**

Unit 8 Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. **(5 lectures)**

Unit 9 Taxonomic hierarchy

Ranks, categories and taxonomic groups **(1 lectures)**

Unit 10 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 lectures)**

Unit 11 Classification

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

Unit 12 Biometrics, numerical taxonomy and cladistics

Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences). **(4 lectures)**

PRACTICALS

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
3. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.
4. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).
   (b)Study of biotic interactions of the following: Stem parasite (*Cuscuta)*, Root parasite (Orobanche), Epiphytes, Predation (Insectivorous plants)
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
7. 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):Brassicaceae -*Brassica, Alyssum / Iberis;* Asteraceae -*Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax;* Solanaceae -*Solanum nigrum, Withania;* Lamiaceae -*Salvia, Ocimum*; Liliaceae - *Asphodelus / Lilium / Allium.*
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

ESSENTIAL READINGS

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). *Plant Systematics:* Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

DISCIPLINE COURSE II

(Semester VII)

DC-II- 5:PLANT ANATOMY AND EMBRYOLOGY

THEORY

Unit 1: Meristematic and permanent tissues
Root and shoot apical meristems; Simple and complex tissues **(7 lectures)**

Unit 2: Organs
Structure of dicot and monocot root stem and leaf. **(4 lectures)**

Unit 3: Secondary Growth
Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood) **(7 lectures)**

Unit 4: Adaptive and protective systems
Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes. **(6 lectures)**

Unit 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 lectures)**

Unit 6: Pollination and fertilization
Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms. **(6 lectures)**

Unit 7: Embryo and endosperm
Endosperm types, structure and functions; Dicot and monocot embryo; Embryo-endosperm relationship **(6 lectures)**

Unit 8: Apomixis and polyembryony
Definition, types and practical applications **(6 lectures)**

PRACTICALS

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
12. Dissection of embryo/endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

ESSENTIAL 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.

DISCIPLINE COURSE II

(Semester VIII)

DC-II- 6:PLANT PHYSIOLOGY AND METABOLISM

THEORY

Unit 1: Plant-water relations

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation. **(5 lectures)**

Unit 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. **(6 lectures)**

Unit 3: Translocation in phloem

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading. **(4 lectures)**

Unit 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. **(10 lectures)**

Unit 5: Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway. **(5 lectures)**

Unit 6: Enzymes

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition. **(4 lectures)**

Unit 7: Nitrogen metabolism

Biological nitrogen fixation; Nitrate and ammonia assimilation. **(4 lectures)**

Unit 8: Plant growth regulators

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene. **(6 lectures)**

Unit 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. **(4 lectures)**

PRACTICALS

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.
8. Separation of amino acids by paper chromatography.

Demonstration experiments (any four)

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots.

ESSENTIAL READINGS

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

APPLIED COURSE

(Semester III)

AC- 1:INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

THEORY

Unit 1: Scope of microbes in industry and environment

Principles and functioning of instruments in microbiology laboratory; Hands on sterilization techniques and preparation of culture media. **(3 lectures)**

Unit 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, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations. **(6 lectures)**

Unit 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) **(9 lectures)**

Unit 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**).** **(3 lectures)**

Unit 5: Microbes and quality of environment.

Distribution of microbes in air; Isolation of microorganisms from soil, air and water. **(3 lectures)**

Unit 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. **(6 lectures)**

Unit 7: Microbes in agriculture and remediation of contaminated soils.

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots. **(6 lectures)**

ESSENTIAL 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.

APPLIED COURSE

(Semester IV)

AC- 2: LANT BREEDING & CROP IMPROVEMENT

THEORY

Unit 1: Plant Breeding

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding. **(5 lectures)**

Unit 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. **(12 lectures)**

Unit 3: Quantitative inheritance

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance. **(4 lectures)**

Unit 4: Inbreeding depression and heterosis

History, genetic basis of inbreeding depression and heterosis; Applications. **(3 lectures)**

Unit 5: Crop improvement and breeding

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement. **(6 lectures)**

ESSENTIAL 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. 2nd edition.
3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

APPLIED COURSE

(Semester V)

AC- 3: NATURAL RESOURCE MANAGEMENT

THEORY

Unit 1: Natural resources
Definition and types. **(1 lecture)**

Unit 2: Sustainable utilization
Concept, approaches (economic, ecological and socio-cultural). **(1 lecture)**

Unit 3: Land
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. **(4 lectures)**

Unit 4: Water
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies. **(3 lectures)**

Unit 5: Biological Resources
Biodiversity-definition and types; Significance; Threats; Management strategies; Bio-prospecting; IPR; CBD; National Biodiversity Action Plan). **(5 lectures)**

Unit 6: Forests
Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management. **(3 lectures)**

Unit 7: Energy
Renewable and non-renewable sources of energy **(3 lectures)**

Unit 8: Contemporary practices in resource management
EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. **(3 lectures)**

Unit 9: National and international efforts in resource management and conservation **(1 lecture)**

Hands on Exercises – (any four)

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) 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.

ESSENTIAL 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.

APPLIED COURSE

(Semester VI)

AC- 4: HORTICULTURAL PRACTICES AND POST-HARVEST TECHNOLOGY

THEORY

Unit 1: Introduction

Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism.

(2 lectures)

Unit 2: Ornamental plants

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coral tree). **(3 lectures)**

Unit 3: Fruit and vegetable crops

Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits). **(3 lectures)**

Unit 4: Horticultural techniques

Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations. **(6 lectures)**

Unit 5: Landscaping and garden design

Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices. **(3 lectures)**

Unit 6: Floriculture

Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions. **(3 lectures)**

Unit 7: Post-harvest technology

Importance of post harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of

preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety. **(6 lectures)**

Unit 8: Disease control and management

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetable crops. **(3 lectures)**

Unit 9: Horticultural crops - conservation and management

Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

(6 lectures)

Unit 10: Field trip

Compulsory field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

ESSENTIAL READINGS

1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.
3. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.
4. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications, USA.
5. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.