CHOICE BASED CREDIT SYSTEM

B.Sc. BOTANY HONOURS

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Preamble

Today plant science is a fusion of the traditional components with the modern aspects of biochemistry, molecular biology and biotechnology. Over the years, plant science (Botany) has shown enormous gain in information and applications owing to tremendous inputs from research in all its aspects. With global recognition of the need for conservation, field plant biologists have contributed significantly in assessing 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. Concern for ever increasing pollution and climate change is at its highest than ever before. Keeping these advancements in view, a revision of the curriculum at the undergraduate level is perfectly timed.

From the beginning 2014-15 session, the Botany students across Indian Universities 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 six semesters. 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 modern tools and techniques in plant science.

Keeping the employment entrepreneurship in mind, applied courses have also been introduced. 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 with the new curriculum will be a complete botanist at honours level.

Semester	CORE COURSE(14)	Ability Enhancement CompulsoryCourse(AEC)(2)	Skill Enhancement Course (SEC) (2)	Discipline SpecificElective (DSE) (4)	GENERIC ELECTIVE: (GE) (4)
I	Algae and Microbiology	English communication			GE-1
	Biomolecules and Cell Biology				
II	Mycology and Phytopathology	Environmental Science			GE-2
	Archegoniate				
III	Morphology and Anatomy		SEC -1		GE-3
	Economic Botany				
	Basics of Genetics				
IV	Molecular Biology		SEC -2		GE-4
	Plant Ecology and Phytogeography				
	Plant Systematics				
V	Reproductive Biology of Angiosperms			DSE-1	
	Plant Physiology			DSE-2	
VI	Plant Metabolism			DSE -3	,
	Plant Biotechnology			DSE-4	

SEMESTER	COURSE OPTED	COURSE NAME	CREDITS
I	Ability Enhancement Compulsory Course I	English Communication/ Environmental Science	2
	Core Course-I	Algae and Microbiology	4
	Core Course-I Practical	Algae and Microbiology	2
	Core Course-II	Biomolecules and Cell Biology	4
	Core Course-II Practical	Biomolecules and Cell Biology	2
	Generic Elective -1	GE-1	4
	Generic Elective -1 Practical/tutorial	GE-1 Practical	2
2	Ability Enhancement Compulsory Course II	English Communication/ Environmental Science	2
	Core Course-III	Mycology and Phytopathology	4
	Core Course-III Practical	Mycology and Phytopathology practical	2
	Core Course-IV	Archegoniate	4
	Core Course-IV Practical	Archegoniate practical	2
	Generic Elective -2	GE-2	4
	Generic Elective -2 Practical/tutorial	GE-2 Practical	2
3	Core Course-V	Morphology and Anatomy	4
	Core Course-V Practical	Morphology and Anatomy-Practical	2
	Core Course-VI	Economic Botany	4
	Core Course-VI Practical	Economic Botany practical	2
	Core Course-VII	Genetics	4
	Core Course-VII Practical	Genetics practical	2
	Skill Enhancement Course-1	SEC-1	4
	Generic Elective -3	GE-3	4
	Generic Elective -3 Practical/tutorial	GE-3 Practical	2
4	Core Course-VIII	Molecular Biology	4
	Core Course-VIII Practical	Molecular Biology practical	2
	Core Course-IX	Plant Ecology and Phytogeography	4
	Core Course-IXPractical	Plant Ecology and Phytogeography Practical	2
	Core Course-X	Plant Systematics	4
	Core Course-X Practical	Plant Systematics practical	2
	Skill Enhancement Course-2	SEC-2	4
	Generic Elective -4	GE-4	4
	Generic Elective -4 Practical/tutorial	GE-4 Practical	2
SEMESTER	**COURSE OPTED**	**COURSE NAME**	**CREDITS**
5	Core Course-XI	Reproductive Biology of Angiosperms	4

	Core Course-XI Practical	Reproductive Biology of Angiosperms practical	2
	Core Course-XII	Plant Physiology	4
	Core Course-XII Practical	Plant Physiology Practical	2
	Discipline Specific Elective 1	DSE-1	4
	Discipline Specific Elective 1 Practical	DSE-1 Practical	2
	Discipline Specific Elective 2	DSE-2	4
	Discipline Specific Elective 2 Practical	DSE-2 Practical	2
6	Core Course-XIII	Plant Metabolism	4
	Core Course-XIII Practical	Plant Metabolism Practical	2
	Core Course-XIV	Plant Biotechnology	4
	Core Course-XIV Practical	Plant Biotechnology Practical	2
	Discipline Specific Elective 3	DSE-3	4
	Discipline Specific Elective 3 Practical	DSE-3 Practical	2
	Discipline Specific Elective 4	DSE-4	4
	Discipline Specific Elective 4 Practical	DSE-4 Practical	2

Structure of B.Sc. Honours Botany under CBCS

Core Courses

Core Course I.	Algae and Microbiology
Core Course II.	Biomolecules and Cell Biology
Core Course IIII.	Mycology and Phytopathology
Core Course I**V**.	Archegoniate
Core Course V.	Morphology and Anatomy
Core Course VI.	Economic Botany
Core Course VII.	Genetics
Core Course VIII.	Molecular Biology
Core Course IX	Plant Ecology and Phytogeography
Core Course X.	Plant Systematics
Core Course XI.	Reproductive Biology of Angiosperms
Core Course XII	Plant Physiology
Core Course XIII	Plant Metabolism
Core Course XIV.	Plant Biotechnology

Discipline Specific Electives

1. Analytical Techniques in Plant Sciences
2. Bioinformatics
3. Stress Biology
4. Plant Breeding
5. Natural Resource Management
6. Horticultural Practices and Post-Harvest Technology
7. Research Methodology
8. Industrial and Environmental Microbiology
9. Biostatistics

Generic Electives

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

Ability Enhancement Course Compulsory

1. Environmental Science
2. English/MIL Communication

Ability Enhancement CoursesElective

1. Biofertilizers
2. Herbal Technology
3. Nursery and Gardening
4. Floriculture
5. Medicinal Botany
6. Plant Diversity and Human Welfare
7. Ethnobotany
8. Mushroom Culture Technology
9. Intellectual Property Rights

CORE COURSES

Semester-I

Core Course I: Microbiology and Phycology

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction to microbial world **(8 lectures)**

Three Domains of life and its evolutionary relationship. Introduction to bacteria, viruses, algae. Microbial nutrition, growth and metabolism.

Unit 2: Viruses **(8 lectures)**

Introduction to virus. Types of virus: DNA virus, RNA virus & Retrovirus. Virus replication: lytic and lysogenic cycle. Viroid and Prions.

Unit 3: Bacteria **(8 lectures)**

Discovery, general characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). Economic importance of bacteria

Unit 4: Algae **(10 lectures)**

General characteristics, Range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification system (Fritsch). Economic importance of algae.

Unit 5: Cyanophyta and Xanthophyta **(8 lectures)**

Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of *Nostoc*and *Vaucheria.*

Unit 6: Chlorophyta and Charophyta **(8 lectures)**

General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Oedogonium andChara.* Evolutionary significance of *Prochloron.*

Unit 7: Phaeophyta and Rhodophyta **(10 lectures)**

Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus* and *Polysiphonia.*

Practical

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. Study of Root nodules and its importance

Phycology

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

Suggested Readings

1. Lee, R.E. (2008). **Phycology**, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) **Prescott's Microbiology. 9th Edition**. McGrawHill International.
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., JacksonR.B. (2008). **Biology**, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) **Microbiology, 5th edition**, Tata McGraw-Hill Co, New Delhi.

Core Course II: Biomolecules and Cell Biology

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Biomolecules **(20 lectures)**

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

Carbohydrates: Nomenclature and classification; Monosaccharides; Disaccharides;Oligosaccharides and polysaccharides.

Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure andfunctions; Essential fatty acids; Triacyl glycerols structure, functions and properties;Phosphoglycerides.

Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary andquarternary; Protein denaturation and biological roles of proteins.

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types ofnucleic acids; Structure of DNA, structure of A, B, Z types of DNA. Types of RNA, structure of tRNA

Unit 2: Bioenergenetics **(4 lectures)**

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupledreactions, redox reactions. ATP: structure, its role as a energy currency molecule.

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

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group;Classification of enzymes; Features of active site, substrate specificity, mechanism of action(activation energy, lock and key hypothesis, induced-fit theroy), Michaelis–Menten equation,enzyme inhibition and factors affecting enzyme activity.

Unit4: The cell **(4 lectures)**

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells;Origin ofeukaryotic cell (Endosymbiotic theory).

Unit 5: Cell wall and plasma membrane (4 lectures)

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluidmosaic model; Membrane transport – Passive, active andfacilitated transport, endocytosis and exocytosis.

Unit 6: Cell organelles (16 lectures)

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.

Chloroplast, mitochondria and peroxisomes: Structural organization; Function;Semiautonomous nature of mitochondria and chloroplast.
Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteinsin the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins andlipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export fromGolgi Apparatus; Lysosomes

Unit 7: Cell division (6 lectures)

Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, roleof protein kinases.

Practical

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.

2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/*Crinum*.

3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.

4. Measurement of cell size by the technique of micrometry.

5. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion usingPeriodic Schiff's (PAS) staining technique.

6. Study the phenomenon of plasmolysis and deplasmolysis.

7. Study of different stages of mitosis

8. Study of different stages of meiosis.

Suggested Readings

1. Campbell, MK (2012) **Biochemistry, 7th ed.,** Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) **Biochemistry Illustrated, 4th ed.,** Published by ChurchillLivingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) **Biochemistry: A short course, 2nd ed.,** W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) **Biochemistry,** W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) **Lehninger Principles of Biochemistry, 5th Edition.,** W.H.Freeman and Company.
6. Karp, G. (2010). **Cell Biology,** John Wiley & Sons, U.S.A. 6thedition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). **Becker's World of the Cell,** Pearson EducationInc. U.S.A. 8thedition.
8. Cooper, G.M. and Hausman, R.E. (2009) **The Cell: A Molecular Approach. 5th edition.** ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) **The World of the Cell. 7th edition.** Pearson Benjamin Cummings Publishing, San Francisco.

Semester-II

Core Course III: Mycology and Phytopathology

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction to fungi (6 lectures)

General characteristics; origin, thallus organization; Cell wall composition; Nutrition; Classification (Ainsworth system).

Unit 2: Chytridiomycota and Zygomycota (5 lecture)

Characteristic features; Thallus organisation; Reproduction; Life cycle with reference to *Synchytrium, Rhizopus*.

Unit 3: Ascomycota (10 lectures)

General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosisand parasexuality; Life cycle and classification with reference to *Saccharomyces, Penicillium, Aspergillus*,and *Alternaria.*

Unit 4: Basidiomycota (8 lectures)

General characteristics; Life cycle and Classification with reference to *Puccinia* and*Agaricus*; Bioluminescence.

Unit 5: Allied Fungi (3 lectures)

General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia;Types of fruiting bodies.

Unit 6: Oomycota(4 lectures)

General characteristics; Life cycle and classification with reference to *Phytophthora*and *Albugo.*

Unit 7: Symbiotic associations (4 lectures)

Lichen – Occurrence; General characteristics;Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza,Endomycorrhiza and their significance.

Unit 8: Applied Mycology (10 Lectures)

Application of fungi in food industry (Flavour& texture,Fermentation, Baking, Organic acids, Enzymes; Secondary metabolites(Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control(Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides).

Unit 9: Phytopathology (10 lectures)

Terms and concepts; General symptoms, Host-Pathogen relationships, Disease cycle and environmental relation;prevention and control of plant diseases, and role of quarantine.

Bacterial diseases – Citrus canker and bacterial leaf wilt of tomato.

Viral diseases – Papaya Mosaic viruses, vein clearing.

Fungal diseases – Early blight of potato, Black stem rust of wheat,White rust of crucifers, powdery mildew, damping off disease.

Practical

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, ascocarps &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 Sexualstage from permanent slides/photographs.
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. *Pleurotus*specimens of button stage and full-grown mushroom; sectioning of gills.
8. *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study through section/temporary mounts and sexual structures through permanent slides.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on differentsubstrates. Study of thallus and reproductive structures (soredia and apothecium) throughpermanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
10. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; bacterial leaf wilt of tomato.
11. Viral diseases in the locality.

Suggested Readings

1. Agrios, G.N. (1997) **Plant Pathology,** 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). **Introductory Mycology**, John Wiley &Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). **Introduction to Fungi,** Cambridge University Press,Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). **Text book of Fungi and Their Allies**, Macmillan PublishersIndia Ltd.
5. Sharma, P.D. (2011). **Plant Pathology,** Rastogi Publication, Meerut, India.

Core Course IV: Archegoniate (Bryophytes, Pteridophytes and Gymnosperms)

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

UNIT 1 Introduction to Bryophytes & Pteridophytes (12 lectures)

Unifying features of archegoniates; Alternation of generations. Bryophytes-General characteristics; Classification; Pteridophytes- General characteristics;Classification; Early land plants (*Rhynia*).

UNIT 2 Type Studies- Bryophytes (12 lectures)

Classification (up to family) (Proskauer, 1957), morphology, anatomy, reproduction and evolutionarytrends of *Marchantia, Anthoceros, Sphagnum and Funaria*; Ecological and economicimportance of bryophytes with special reference to *Sphagnum*.

UNIT 3 Type Studies- Pteridophytes (12 lectures)
Classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamyand apospory, heterospory and seed habit, telome theory, Stelar evolution

UNIT 4 Gymnosperms (12 lectures)
General characteristics, classification (up to family), morphology, anatomy andreproduction of *Cycas*, *Pinus* and *Gnetum*(Developmental details not to be included)

UNIT 5 Paleobotany (12 lectures)
Geological time scale; fossil types and their formation; general account of dominantfossil flora of different ages; paleobotany in relation to exploration of fossil fuels

Practical

1. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical sectionof thallusthrough Gemma cup, whole mount of Gemmae (all temporary slides), vertical section ofAntheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).

2. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata,spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).

3. ***Sphagnum***- Morphology of plant, whole mount of leaf (permanent slide only).

4. ***Funaria***- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores(temporary slides); permanent slides showing antheridial and archegonial heads, longitudinalsection of capsule and protonema.

5. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem, wholemount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides),longitudinal section of strobilus (permanent slide).

6. ***Equisetum***- Morphology, transverse section of internode, longitudinal section of strobilus,transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet anddry) (temporary slide), transverse section of rhizome (permanent slide).

7. ***Pteris***- Morphology, transverse section of rachis, vertical section of sporophyll, wholemount ofsporangium, whole mount of spores (temporary slides), transverse section of rhizome, wholemount of prothallus with sex organs and young sporophyte (permanent slide).

8. ***Cycas***- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transversesection of coralloid root, transverse section of rachis, vertical section of leaflet,

vertical sectionof microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule,transverse section of root (permanent slide).

9. ***Pinus***- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and femalecones), 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 &radiallongitudinal sections stem (permanent slide).

10. ***Gnetum***- Morphology (stem, male & female cones), transverse section of stem, verticalsection of ovule (permanent slide)

11. **Botanical excursion.**

Suggested 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.

5. Vanderpoorten, A. &Goffinet, B. (2009) **Introduction to Bryophytes**. Cambridge UniversityPress.

Semester-III

Core Course V: Anatomy of Angiosperms

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction to Structure and Development of Plant Body (8 Lectures)

Internal organization of plant body: The three tissue systems, types of cells and tissues.Development of plant body: Polarity,

Unit 2: Tissues (12 Lectures)

Classification of tissues; Simple and complex tissues (no phylogeny); Wall ingrowths and transfer cells, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Unit 3: Apical meristems (15 Lectures)

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, TunicaCorpus theory, Types of vascular bundles; Structure of dicot and monocot stem. Development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root;

Unit 4: Vascular Cambium and Wood (15 Lectures)

Structure, function and seasonal activity of cambium; Secondary growth in root and stem.Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. periderm, rhytidome and lenticels.

Unit 5: Adaptive and Protective Systems (10 Lectures)

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

Practical

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/museum specimens with the help of suitable examples.
2. Distribution and types of aerenchyma, parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates;xylemfibres.
4. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
5. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
6. Root: monocot, dicot, secondary growth.
7. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
8. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
9. Adaptive Anatomy: xerophytes, hydrophytes.
10. Secretory tissues: cavities, lithocysts and laticifers.

Suggested 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. Evert, R.F. (2006) Esau's **Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: TheirStructure, Function and Development.** John Wiley and Sons, Inc.

Core Course VI: Economic Botany

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Origin of Cultivated Plants (6 lectures)

Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples ofmajor plant introductions; Crop domestication and loss of genetic diversity; evolution of newcrops/varieties, importance of germplasm diversity.

Unit 2: Cereals (6 lectures)

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

Unit 3: Legumes (6 lectures)

Origin, morphology and uses of soybean, phaseolus legumes. Importance to man.

Unit 4: Sources of sugars and starches(4 lectures)

Morphology and processing of sugarcane, products and by-products of sugarcane industry.Potato – morphology, propagation & uses.

Unit 5: Spices(6 lectures)

Listing of important spices, their family and part used. Economic importance with specialreference to ginger, cardamom, cinnamon, and black pepper

Unit 6: Beverages (4 lectures)

Tea, Coffee (morphology, processing & uses)

Unit 7: Sources of oils and fats (10 lectures)

General description, classification, extraction, their uses and health implications groundnut, sesame, coconut, linseed, mustard and coconut (Botanical name, family & uses).

Unit 8: Natural Rubber (3 lectures)

Para-rubber: tapping, processing and uses.

Unit 9: Drug-yielding plants (8 lectures)

Therapeutic and habit-forming drugs with special reference to C*inchona, Digitalis, Papaver* and*Cannabis*;

Unit 10: Timber plants (3 Lectures)

General account with special reference to teak and pine.

Unit 11: Fibers (4 lectures)

Types based on the origin of fibers; Cotton and Jute (morphology, extraction anduses).

Practical

1. **Cereals**: Wheat (habit sketch, L. S/T.S. grain, starch grains), Rice(habit sketch, study of paddy and grain, starch grains).
2. **Legumes**: Groundnut, (habit, fruit, seed structure).
3. **Sources of sugars and starches**: Sugarcane (habit sketch),Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains)
4. **Spices:** Black pepper, ginger (habit and sections).

5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats**: Coconut, Mustard–plant specimen, seeds
7. **Essential oil-yielding plants**: Habit sketch of *Rosa*, *Vetiveria, Santalum* and *Eucalyptus*(specimens/photographs).
8. **Rubber**: specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants**: collection and herbarium
10. Woods: collection of specimen
11. **Fiber-yielding plants**: Cotton and jute: collection

Suggested Readings

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

Core Course VII: Genetics

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Mendelian genetics and its extension (16 lectures)

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomesand sex chromosomes; Probability and pedigree analysis; Incomplete dominance andcodominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominanttraits, Numericals; Polygenic inheritance.

Unit 2: Extrachromosomal Inheritance (6 lectures)

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

Unit 3: Linkage, crossing over and chromosome mapping (**12 lectures)**

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, twofactor and three factor crosses; Interference and coincidence; Numericals based on genemapping; Sex Linkage.

Unit 4: Variation in chromosome number and structure (8 lectures)

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

Unit 5: Gene mutations (6 lectures)

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Baseanalogs, deaminating, alkylating and intercalating agents) Role of Transposons in mutation.DNA repair mechanisms.

Unit 6: Fine structure of gene (6 lectures)

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism.

Unit 7. Population and Evolutionary Genetics (6 lectures)

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection,mutation, genetic drift. Genetic variation and Speciation.

Practical

1. Meiosis through temporary squash preparation.

2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.

3. Chromosome mapping using point test cross data.

4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.

5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1,9:3:4).

6. Blood Typing: ABO groups & Rh factor.

7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.

8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.

9. 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.

Suggested 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 GeneticAnalysis**. W. H. Freeman and Co., U.S.A. 10th edition.

Semester-IV

Core Course VIII: Molecular Biology

THEORY (Credit :4) **Lectures: 60**

Unit 1: Nucleic acids : Carriers of genetic information (4 lectures)

DNA as the carrier of genetic information (Griffith's, Hershey & Chase,Avery, McLeod & McCarty experiments)

Unit 2. The Structures of DNA and RNA / Genetic Material (10 lectures)

DNA Structure: Salient features of double helix (Watson and Crick), Types of genetic material, denaturation and renaturation; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure, mitochondria and chloroplast DNA. The Nucleosome, Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 2:The replication of DNA (10 lectures)

General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; replication of DNA in prokaryoyes and eukaryotes; Enzymes involved in DNA replication.

Unit 3: Central dogma and genetic code (2 lectures)

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

Unit 4: Transcription (18 lectures)

Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation;Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Gene silencing.

Unit 5: Processing and modification of RNA (8 lectures)

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

Unit 6: Translation (8 lectures)

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases;Various steps in protein synthesis, proteins involved in initiation, elongation and termination ofpolypeptide; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Practical

1. DNA isolation from any plant.
2. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
3. Study of DNA replication mechanisms through photographs
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; Splicingmechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested 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). **Genetics- A Molecular Approach**. Benjamin Cummings, U.S.A. 3rdedition.
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.

Core Course IX: Plant Ecology and Phytogeography

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(4 lectures)**

Basic concepts; Levels of organization. Inter-relationships between the living world and theenvironment, the components and dynamism, homeostasis.

Unit 2: Soil **(8 lectures)**

Origin; Formation; Composition (Physical; Chemical and Biological components),Soil profile

Unit 3: Water **(4 lectures)**

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

Unit 4: Light, temperature, wind and fire **(6 lectures)**

Variations; adaptations of plants to their variation.

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

Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis,commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standingcrop.

Unit 6: Population ecology **(4 lectures)**

Characteristics and Dynamics. Ecological Speciation

Unit 7: Plant communities **(8 lectures)**

Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic;Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit 8: Ecosystems **(4 lectures)**

Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids.

Unit 9: Functional aspects of ecosystem **(8 lectures)**

Principles and models of energy flow; Production and productivity; Ecological efficiencies;Biogeochemical cycles; Cycling of Nitrogen and Phosphorus.

Unit 10: Phytogeography **(12 lectures)**

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical divisionof India; Local Vegetation.

Practical

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 fromtwo soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by 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.
   (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 collegecampus, 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.

Suggested Readings

1. Odum, E.P. (2005). **Fundamentals of ecology.** Cengage Learning India Pvt. Ltd., New Delhi. 5thedition.
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.

Core Course X: Plant Systematics

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Significance of Plant systematics (15 lectures)

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences frompalynology. 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.

Unit 2: Taxonomic hierarchy (8 lectures)

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

Unit 3: Botanical nomenclature (12 lectures)
Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication,rejection of names, principle of priority and its limitations; Names of hybrids.
Unit 4: Systems of classification (13 lectures)
Major contributions of Linnaeus, Hutchinson; Classification systems of Bentham and Hooker(upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm PhylogenyGroup (APG III) classification.
Unit 5: Phylogeny of Angiosperms (12 lectures)
Terms and concepts (primitive and advanced, homology and analogy, parallelism andconvergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution ofangiosperms; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower,section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham& Hooker's system of classification):
Ranunculaceae - *Ranunculus, Delphinium*
Brassicaceae - *Brassica, Alyssum / Iberis*
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).

Suggested Readings

1. Singh, (2012). **Plant Systematics: Theory and Practice** Oxford & IBH Pvt. Ltd., New Delhi.3rdedition.
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. Radford, A.E. (1986). **Fundamentals of Plant Systematics.** Harper and Row, New York.

Semester-V

Core Course XI: Reproductive Biology of Angiosperms

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction and Reproductive development (6 lectures)

History and scope of embryology. Induction of flowering; flower as a modified determinate shoot.

Unit 2: Anther and pollen biology (10 lectures)

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.Microgametogenesis, Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit 3: Ovule (10 lectures)

Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Femalegametophyte–megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis. details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

Unit 4: Pollination and fertilization (8 lectures)

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tubein pistil; double fertilization.

Unit 5: Self incompatibility (10 lectures)

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Modification of stigma surface. Parasexual hybridization, cybrids, in vitro fertilization.

Unit 6: Embryo, Endosperm and Seed (10 lectures)

Structure and types; General pattern of development of dicot and monocot embryo andendosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition ofembryo. Seed structure, importance and dispersal mechanisms

Units 7: Polyembryony and apomixis (6 lectures)

Introduction; Classification; Causes and applications.

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads,uninucleate, bicelled and dehisced anther stages through slides/micrographs
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads,polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph);
3. Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in differentmedia 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 throughelectron micrographs.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). **The Embryology of Angiosperms,** Vikas PublishingHouse. 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.

Core Course XII: Plant Physiology

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Plant-water relations (10 lectures)

Water Potential and its components, water absorption by roots, pathway of watermovement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap–cohesion-tension theory.Transpiration and factors affecting transpiration, antitranspirants,mechanism of stomatal movement.

Unit 2: Mineral nutrition **(8 lectures)**

Essential and beneficial elements, macro and micronutrients, methods of study and use of
nutrient solutions, roles of essential elements, deficiency symptoms.

Unit 3: Nutrient Uptake **(8 lectures)**

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption,electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carriersystems,proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 4: Translocation in the phloem **(8 lectures)**

Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators **(14 lectures)**

Physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of flowering **(6 lectures)**

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

Unit 7: Phytochrome ,crytochromes and phototropins **(6 lectures)**

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and highirradiance responses (HIR), mode of action.

Practical

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 rate transpiration by Ganong's potometer
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of amesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in amesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).

Suggested 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., Zeiger, E., Møller, I.M. and Murphy, A (2015). **Plant Physiology and Development.**Sinauer Associates Inc. USA. 6th edition.

3. Bajracharya D. (1999). **Experiments in Plant Physiology-A Laboratory Manual**. NarosaPublishing House, New Delhi.

Semester-VI

Core Course XIII: Plant Metabolism

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Concept of metabolism (6 lectures)

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatoryenzymes (allosteric ,covalent modulation and Isozymes).

Unit 2: Carbon assimilation (14 lectures)

photosynthetic pigments, role of photosynthetic pigments (chlorophyllsand accessory pigments), antenna molecules and reaction centres, photochemical reactions,photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration,C_4pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit 3: Carbohydrate metabolism (2 lectures)

Synthesis and catabolism of sucrose and starch.

Unit 4: Carbon Oxidation (10 lectures)

Glycolysis, fate of pyruvate, oxidative pentose phosphate pathway,oxidative decarboxylation of pyruvate; TCA cycle,amphibolic role, anaplerotic reactions, mitochondrial electron transport, oxidative phosphorylation.

Unit 5: ATP-Synthesis (8 lectures)

Mechanism of ATP synthesis, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase

Unit 6: Lipid metabolism (8 lectures)

Synthesis and breakdown of triglycerides, β-oxidation and its role in mobilisation of lipids during seed germination.

Unit 7: Nitrogen metabolism (8 lectures)

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

Unit 8: Mechanisms of signal transduction (4 lectures)

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin.

Practical

1. Chemical separation of photosynthetic pigments.
2. To study the effect of light intensity on the rate of photosynthesis.
3. Effect of carbon dioxide on the rate of photosynthesis.
4. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested 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., Zeiger, E., Møller, I.M. and Murphy, A (2015). **Plant Physiology and Development.**Sinauer Associates Inc. USA. 6th edition.

3. Harborne, J.B. (1973). **Phytochemical Methods**. John Wiley & Sons. New York.

Core Course XIV: Plant Biotechnology

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Plant Tissue Culture **(16 lectures)**

Composition of media; Nutrient and hormone requirements (role ofvitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic);Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, Cryopreservation; Germplasm Conservation).

Unit 2: Recombinant DNA technology (12 lectures)

Restriction Endonucleases (Types I-IV, biological role and application); RestrictionMapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Tiplasmid, BAC); Lambda phage, M13 phagemid, Shuttle vector; Eukaryotic Vectors-(YAC).

Unit 3:Gene Cloning **(10 lectures)**

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screeningDNA libraries to obtain gene of interest by genetic selection; complementation, colonyhybridization; PCR

Unit 4: Methods of gene transfer (8 lectures)

Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection,Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes(Luciferase, GUS, GFP).

Unit 5: Applications of Biotechnology (14 lectures)

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic cropswith improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties(Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines;Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products; Humulin; Biosafety concerns.

Practical

1. (a) Preparation of MS medium.
(b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis &artificial seeds through photographs.
3. Isolation of protoplasts.
4. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct genetransfer by electroporation, microinjection, microprojectile bombardment.
5. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs.
6. Isolation of plasmid DNA.
7. Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). **Plant Tissue Culture: Theory and Practice**. ElsevierScience Amsterdam. The Netherlands.

2. Glick, B.R., Pasternak, J.J. (2003). **Molecular Biotechnology- Principles and Applications ofrecombinant DNA.** ASM Press, Washington.

3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). **The Embryology of Angiosperms**. Vikas PublicationHouse 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 andApplications.** John Wiley & Sons Inc. U.S.A.

Discipline Specific Elective Courses

Discipline Specific Elective

Analytical Techniques in Plant Sciences

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Imaging and related techniques **(15 lectures)**

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy;Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescencemicroscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanningelectron microscopy – sample preparation for electron microscopy, cryofixation, negativestaining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation **(8 lectures)**

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes **(4 lectures)**

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry **(4 lectures)**

Principle and its application in biological research.

Unit 5: Chromatography **(8 lectures)**

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchangechromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids **(6 lectures)**

Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins andnucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit 7:Biostatistics **(15 lectures)**

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical;Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range,mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting,DNA sequencing, PCR through photographs.
2. To separate nitrogenous bases by paper chromatography.
3. To separate sugars by thin layer chromatography.
4. To separate chloroplast pigments by column chromatography.
5. To estimate protein concentration through Bradford's methods.
7. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
8. Preparation of permanent slides (double staining).

Suggested Readings

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

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

THEORY **Lectures: 60**

Unit 1. Introduction to Bioinformatics (5 Lectures)

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics (5 Lectures)

Introduction, Biological Databases, Classification format of Biological Databases, Biological
Database Retrieval System.

Unit 3. Biological Sequence Databases (25 Lectures)

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, DatabaseRetrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST),Nucleotide Database, Protein Database, Gene Expression Database.
EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ.Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, DataRetrieval in PIR.Swiss-Prot: Introduction and Salient Features.

Unit 4. Sequence Alignments (10 Lectures)

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA byCLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino AcidSubstitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny (8 Lectures)

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of MolecularPhylogenetic Prediction.

Unit 6. Applications of Bioinformatics (7 Lectures)

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR)techniques in Drug Design, Microbial genome applications, Crop improvement

Practical

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

Suggested Readings

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

Discipline Specific Elective

Stress Biology

Credits: Theory 4, Practical 2

Theory **Lectures:60**

Unit 1: Defining plant stress **(2 lectures)**
Acclimation and adaptation.

Unit 2: Environmental factors **(20 lectures)**
Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction;Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect anddisease resistance by jasmonates.

Unit 3: Stress sensing mechanisms in plants **(20 lectures)**
Calcium modulation, Phospholipid signaling

Unit 4: Developmental and physiological mechanisms that protect plants against environmental stress **(12 lectures)**
Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmoticadjustment; Compatible solute production.

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

Practical

1. Quantitative estimation of peroxidase/Superoxide dismutase activity in the seedlings in the absenceand presence of salt stress.
2. Superoxide isoforms in the absence and presence of salt stress using SDS-PAGE.
3. Zymographic analysis of peroxidase.
4. Quantitative estimation and zymographic analysis of catalase.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). **Introduction to Plant Physiology**. John Wiley andSons. U.S.A. 4th edition.

2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). **Plant Physiology andDevelopment.** Sinauer Associates Inc. USA. 6th edition.

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

THEORY **Lectures: 60**

Unit 1: Plant Breeding **(10 lectures)**

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Importantachievements and undesirable consequences of plant breeding.

Unit 2: Methods of crop improvement **(20 lectures)**

Introduction: Centres of origin and domestication of crop plants, plant genetic resources;Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetativelypropagated plants; Hybridization: For self, cross and vegetatively propagated plants– Procedure,advantages and limitations.

Unit 3: Quantitative inheritance **(10 lectures)**

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in humanbeings.Monogenic vs polygenic Inheritance.

Unit 4: Inbreeding depression and heterosis **(10 lectures)**

History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding **(10 lectures)**

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

PRACTICALS

1. Perform hand pollination in some locally available flowers or vegetables. Note the detailed process and the results obtained.
2. Perform emasculation and cross pollination on some plants.
3. Visit agriculture research institutes/stations/centers, prepare a report on the accessions of vegetables/seeds/crops available.

Suggested Readings

1. Singh, B.D. (2005). **Plant Breeding**: Principles and Methods. Kalyani Publishers. 7thedition.

2. Chaudhari, H.K. (1984). **Elementary Principles of Plant Breeding.** Oxford – IBH.2ndedition.

3. Acquaah, G. (2007). **Principles of Plant Genetics & Breeding**. Blackwell Publishing.

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

THEORY **Lectures: 60**

Unit 1: Natural resources **(2 lectures)**

Definition and types.

Unit 2: Sustainable utilization **(8 lectures)**

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

Unit 3: Land **(8 lectures)**

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

Unit 4: Water **(8 lectures)**

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

Unit 5: Biological Resources **(12 lectures)**

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

Unit 6: Forests **(6 lectures)**

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

Unit 7: Energy **(6 lectures)**

Renewable and non-renewable sources of energy

Unit 8: Contemporary practices in resource management **(8 lectures)**

EIA, GIS, Ecological Footprint with emphasis on carbon footprint; Waste management.

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

(4 lectures)

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.

2. Collection of data on forest cover of specific area.

3. Measurement of dominance of woody species by DBH (diameter at breast height)method.

4. Calculation and analysis of ecological footprint.

5. Ecological modeling.

Suggested Readings

1. Vasudevan, N. (2006). **Essentials of Environmental Science**. Narosa Publishing House,New Delhi.

2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). **Ecology, Environment and ResourceConservation.** Anamaya Publications, New Delhi.

3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). **An Introduction to SustainableDevelopment.** Prentice Hall of India Private Limited, New Delhi.

Discipline Specific Elective
Horticultural Practices and Post-Harvest Technology
(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(4 lectures)**

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

Unit 2: Ornamental plants **(4 lectures)**

Types, classification (annuals, perennials, climbers and trees); Identification and salient featuresof 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,coraltree).

Unit 3: Fruit and vegetable crops **(4 lectures)**

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

Unit 4: Horticultural techniques **(8 lectures)**

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

Unit 5: Landscaping and garden design **(6 lectures)**

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

Unit 6: Floriculture **(6 lectures)**

Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows andexhibitions.

Unit 7: Post-harvest technology **(10 lectures)**

Importance of post-harvest technology in horticultural crops; Evaluation of quality traits;Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods ofpreservation and processing; Methods of minimizing loses during storage and transportation;Food irradiation - advantages and disadvantages; food safety.

Unit 8: Disease control and management **(8 lectures)**

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures andnutritional management practices; Crop sanitation; IPM strategies (genetic, biologicalAndchemical methods for pest control); Quarantine practices; Identification of common diseasesandpests of ornamentals, fruits and vegetable crops.

Unit 9: Horticultural crops - conservation and management **(10 lectures)**

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

Practical

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

2. Grow some ornamental/horticultural plants in nurseries. Make a detailed report of the same.

Suggested Readings

1. Singh, D. &Manivannan, S. (2009). **Genetic Resources of Horticultural Crops**. RidhiInternational, 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 ofIndustrial 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.

Discipline Specific Elective
Research Methodology
Credit: Theory 4; Practical 2

Theory **Lectures: 60**

Unit 1: Basic concepts of research **(10 lectures)**

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental;

quantitative vs qualitative; conceptual vs emperical). Research methods vsmethodology.Literature-review and its consolidation; Library research; field research; laboratoryresearch.

Unit 2: General laboratory practices **(12 lectures)**

Common calculations in botany laboratories. Understanding the details on the label of reagentbottles. 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.

Unit 3: Data collection and documentation of observations **(6 lectures)**

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging oftissuespecimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems **(6 lectures)**

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

Unit 5: **Methods to study plant cell/tissue structure** **(6 lectures)**

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissuepreparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulantfixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration;Preparation of thin and ultrathin sections.

Unit 6: Plant micro-techniques **(12 lectures)**

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

Unit 7: The art of scientific writing and its presentation **(8 lectures)**

Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references.Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction tocopyright-academic misconduct/plagiarism.

Practical

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.

Suggested 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, NewYork, U.S.A.

Discipline Specific Elective
Industrial and Environmental Microbiology
(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Scope of microbes in industry and environment **(6 lectures)**

Unit 2: Bioreactors/Fermenters and fermentation processes **(12 lectures)**

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuousfermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscaleand production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed andfluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products **(12 lectures)**

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 orglutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

Unit 4: Microbial enzymes of industrial interest and enzyme immobilization

(8 lectures)

Microorganisms for industrial applications_and hands on screening microorganisms for caseinhydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages andapplications of immobilization, large scale applications of immobilized enzymes (glucoseisomerase and penicillin acylase**).**

Unit 5: Microbes and quality of environment. **(6 lectures)**

Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Unit 6: Microbial flora of water. **(8 lectures)**

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 ofwater quality, check coliform and fecal coliform in water samples.

Unit 7: Microbes in agriculture and remediation of contaminated soils. (8 lectures)

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of rootnodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstreamprocessing operations.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). **Microbiology: An application-based approach.** Tata McGraw Hill Education Pvt. Ltd., Delhi.

2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). **Microbiology.** Pearson BenjaminCummings, San Francisco, U.S.A. 9th edition.

3. Dubey R.C. & Maheshwari D.K. **A textbook of Microbiology.** S.Chand, New Delhi India.

Discipline Specific Elective
Biostatistics
(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1:Biostatistics **(12 lectures)**
Definition - statistical methods - basic principles. Variables - measurements, functions,limitations and uses of statistics.

Unit 2:Collection of data primary and secondary **(12 lectures)**
Types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods.

Unit 3:Measures of central tendency **(14 lectures)**
Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range,standard deviation, mean deviation, quartile deviation - merits and demerits; Co-efficient ofvariations.

Unit 4:Correlation **(12 lectures)**
Types and methods of correlation, regression, simple regression equation, fitting prediction,similarities and dissimilarities of correlation and regression

Unit 5:Statistical inference **(10 lectures)**
Hypothesis - simple hypothesis - student 't' test - chi square test.

Practicals

1) Calculation of mean, standard deviation and standard error

2) Calculation of correlation coefficient values and finding out the probability

3) Calculation of 'F' value and finding out the probability value for the F value.

Suggested Readings

1. Danniel, W.W., 1987.**Biostatistic,**New York, John Wiley Sons.

2.Sundarrao, P.S.S and Richards, J. Christian. **An introduction to Biostatistics, 3rd edition**Medical College, Vellore

3. Selvin, S., 1991. **Statistical Analysis of epidemiological data.** New York University Press.

4.Boston, Bishop, O.N. Houghton, **Statistics for Biology.** Mifflin.

5. Freedman, P. New York, **. The Principles of scientific research.** Pergamon Press.

6. Campbell, R.C., 1998.**Statistics for Biologists.** Cambridge University Press.

Generic Elective Courses

Generic Elective

Biodiversity (Microbes, Algae, Fungi and Archegoniate)

(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Microbes **(10 lectures)**

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.

Unit 2: Algae **(12 lectures)**

General characteristics; Ecology and distribution; Range of thallus organization andreproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*,

Chlamydomonas, Oedogonium, *Vaucheria, Fucus, Polysiphonia*. Economic importance of algae.

Unit 3: Fungi **(12 lectures)**

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

Unit 4: Introduction to Archegoniate **(2 lectures)**

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

Unit 5: Bryophytes **(10 lectures)**

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

Unit 6: Pteridophytes **(8 lectures)**

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, stellar evolution.Ecological and economical importance of Pteridophytes.

Unit 7: Gymnosperms **(6 lectures)**

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

Practical

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic andLysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; BinaryFission; Conjugation; Structure of root nodule.
3. Gram staining
4. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electronmicrographs), *Oedogonium, Vaucheria, Fucus* and Polysiphonia*through temporarypreparations and permanent slides. (* *Fucus*- Specimen and permanent slides)
5. *Rhizopus and Penicillium*: Asexual stage from temporary mounts and sexualstructuresthrough permanent slides.
6. *Alternaria:* Specimens/photographs and tease mounts.
7. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infectedBarberryleaves; section/tease mounts of spores on Wheat and permanent slides of boththe hosts.
8. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of*Agaricus*.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
10. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
11. *Marchantia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus throughgemmacup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s.sporophyte (all permanent slides).
12. *Funaria*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus,spores(temporary slides); permanent slides showing antheridial and archegonial heads,l.s. capsule and protonema.
13. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus,w.m.microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanentslide).
14. *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 (permanentslide).
15. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores(temporary
16. slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanentslide).
17. *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).
18. *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).

Suggested Readings

1. Kumar, H.D. (1999). **Introductory Phycology.** Affiliated East-West. Press Pvt. Ltd. Delhi.2nd edition.

2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). **Microbiology: An Introduction**, Pearson Benjamin Cummings, U.S.A. 10th edition.

3. Sethi, I.K. and Walia, S.K. (2011). **Text book of Fungi & Their Allies,** MacMillanPublishers Pvt. Ltd., Delhi.

4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996**). Introductory Mycology,** JohnWiley and Sons (Asia), Singapore. 4th edition.

5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). **Biology.** Tata McGrawHill, Delhi, India.

6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). **Pteridophyta,** S. Chand. Delhi, India.

7. Bhatnagar, S.P. and Moitra, A. (1996). **Gymnosperms.** New Age International (P) LtdPublishers, New Delhi, India.

8. Parihar, N.S. (1991). **An introduction to Embryophyta.** Vol. I. Bryophyta. Central BookDepot, Allahabad.

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

THEORY **Lectures: 60**

Unit 1: Introduction **(2 lectures)**

Unit 2: Ecological factors **(10 lectures)**

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment,precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelfordlaw of tolerance.

Unit 3: Plant communities **(6 lectures)**

Characters; Ecotone and edge effect; Succession; Processes and types

Unit 4: Ecosystem **(8 lectures)**

Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramidsproduction and productivity; Biogeochemical cycling; Cycling of nitrogen

Unit 5: Phytogeography **(4 lectures)**

Principle biogeographical zones; Endemism

U nit 6 Introduction to plant taxonomy **(2 lectures)**

Identification, Classification, Nomenclature.

Unit 7 Identification **(4 lectures)**

Functions of Herbarium, important herbaria and botanical gardens of the world and India;

Unit 8 Taxonomic evidences from palynology, cytology. **(6 lectures)**

Unit 9 Taxonomic hierarchy **(2 lectures)**

Ranks, categories and taxonomic groups

U nit 10 Botanical nomenclature **(6 lectures)**

Principles and rules (ICN); ranks and names; binominal system

Unit 11 Classification **(6 lectures)**

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

Unit 12 Biometrics, numerical taxonomy and cladistics **(4 lectures)**

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

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer,maximum and minimum thermometer, anemometer, psychrometer/hygrometer, raingauge 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 threehabitats.

4. (a) Study of morphological adaptations of hydrophytes and xerophytes

(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 thecollege 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 positionaccording 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 herbariumlabel (to be submitted in the record book).

Suggested Readings

1. Kormondy, E.J. (1996). **Concepts of Ecology.** Prentice Hall, U.S.A. 4thedition.

2. Sharma, P.D. (2010) **Ecology and Environment**. Rastogi Publications, Meerut, India. 8thedition.

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., NewDelhi. 3rd edition.

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

THEORY **Lectures: 60**

Unit 1: Meristematic and permanent tissues **(8 lectures)**

Root and shoot apical meristems; Simple and complex tissues

Unit 2: Organs **(4 lectures)**

Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth **(8 lectures)**

Vascular cambium – structure and function, seasonal activity. Secondary growth in root andstem, Wood (heartwood and sapwood)

Unit 4: Adaptive and protective systems **(8 lectures)**

Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit 5: Structural organization of flower **(8 lectures)**

Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs,organization and ultrastructure of mature embryo sac.

Unit 6: Pollination and fertilization **(8 lectures)**

Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages anddispersal mechanisms.

Unit 7: Embryo and endosperm **(8 lectures)**

Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endospermrelationship

Unit 8: Apomixis and polyembryony **(8 lectures)**

Definition, types and Practical applications

Practical

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* (Permanentslides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (Permanentslides).
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) (Permanentslides).
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.

Suggested Readings

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). **Embryology of Angiosperms**. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.

2. Mauseth, J.D. (1988). **Plant Anatomy.** The Benjamin/Cummings Publisher, USA.

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

THEORY **Lectures: 60**

Unit 1: Plant-water relations **(8 lectures)**

Importance of water, water potential and its components; Transpiration and its significance;Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition **(8 lectures)**

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role ofessential elements; Transport of ions across cell membrane, active and passive transport,carriers, channels and pumps.

Unit 3: Translocation in phloem. **(6 lectures)**

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading andunloading

Unit 4: Photosynthesis **(12 lectures)**

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reactioncenter, antenna molecules; Electron transport and mechanism of ATP synthesis; C_3, C_4 andCAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration **(6 lectures)**

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate,Oxidative Pentose Phosphate Pathway.

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

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Unit 7: Nitrogen metabolism **(4 lectures)**

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators **(6 lectures)**

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Unit 9: Plant response to light and temperature **(6 lectures)**

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), redand far red light responses on photomorphogenesis; Vernalization.

Practical

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 on plants.
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 enzymeconcentration.
6. To study the effect of light intensity and bicarbonate concentration on O_2 evolution inphotosynthesis.
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 three)

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

Suggested Readings

1. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology andDevelopment. Sinauer Associates Inc. USA. 6thedition.

2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley &Sons, U.S.A. 4thEdition.

3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual.Narosa Publishing House, New Delhi.

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

THEORY **Lectures: 60**

Unit 1: Origin of Cultivated Plants **(4 lectures)**

Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2: Cereals **(4 lectures)**

Wheat -Origin, morphology, uses

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

General account with special reference to phaseolus, Dolichos

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

General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

U nit 5: Beverages **(4 lectures)**

Tea (morphology, processing, uses)

Unit 6: Oils and Fats **(4 lectures)**

General description with special reference to groundnut

Unit 7: Fibre Yielding Plants **(4 lectures)**

Generaldescription with special reference to Cotton (Botanicalname, family, part used,morphology and uses)

Unit 8: Introduction to biotechnology **(2 lecture)**

U nit 9: Plant tissue culture **(8 lectures)**

Micropropagation; haploid production through androgenesis; callus

Unit 10: Recombinant DNA Techniques **(18 lectures)**

Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting;Molecular DNA markers i.e. RAPD, RFLP; DNA sequencing, PCR and ReverseTranscriptase-PCR.

Practical

1. Study of economically important plants-legume, cereals and spices
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

Suggested Readings

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers IndiaLtd., New Delhi. 4thedition.

2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice.Elsevier Science Amsterdam. The Netherlands.

3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles andApplications of recombinant DNA. ASM Press, Washington.

Generic Elective
Environmental Biotechnology
(Credits: Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Environment **(4 lectures)**

Basic concepts and issues, global environmental problems - ozone depletion, greenhouse effect and acid rain due to anthropogenic activities,

Unit 2: Environmental problems **(6 lectures)**

Environmental pollution - types of pollution, sources of pollution, measurement of pollution, Bioconcentration,bio/geo-magnification.

Unit 3:Microbiology of waste water treatment **(8 lectures)**

Aerobic process - activated sludge, oxidation ponds, trickling filter, Anaerobic process-anaerobic digestion, anaerobic filters. Treatment for waste waters

Unit 4: Role of immobilized cells/enzymes in treatment of toxic compounds **(6 lectures)**

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollutionabatement and odour control.

Unit 5:Sustainable Development **(8 lectures)**

Economics and Environment: Economic growth, Gross National Productivity and the qualityof life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and costeffectiveness analysis, WTO and Environment, Corporate Social Responsibility,Environmental awareness and Education; Environmental Ethics.

Unit 6: **International Legislations, Policies for Environmental Protection** **(6 lectures)**

Stockholm Conference (1972) and its declaration, WCED (1983), Rio Earth Summit-UNCED(1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol- 1997, RamsarConvention 1971.

Unit 7: **National Legislations, Policies for Pollution Management** **(6 lectures)**

Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control)Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981,National Environmental Policy -2006

Unit 8: **Public Participation for Environmental Protection** **(6 lectures)**

Environmental movement and people's participation with special references toChilika and Narmada BachaoAndolan, Chipko and Silent valley Movement;Women and Environmental Protection, Role of NGO in bringing environmental awarenessand education in the society.

Practical

1. Water/Soil analysis - DO, salinity, pH, chloride, total hardness, alkalinity, acidity,nitrate, calcium, Magnesium and phosphorus.
2. Microbial assessment of air (open plate and air sample) and water

Suggested Readings

1. Metcalf and Eddy Inc., **Waste water engineering - treatment, disposal and reuse** TataMcGraw Hill, New Delhi.
2. AK. De, **Environmental Chemistry** Wiley Eastern Ltd, New Delhi.
3. D.Allsopp and K.J. Seal, **Introduction to Biodeterioration** ELBS / Edward Arnold.
4. Baaker, KH and Herson D.S., 1994. **Bioremidation.** Mc.GrawHill Inc, NewYork.
5. Nuzhat Ahmed, Fouad M. Qureshi andObaid Y. Khan, 2006. **Industrial and Environmental Biotechnology** Horizon Press.
6. Paul A, Rochelle, **Environmental Molecular Biology,** 2001.Horizon Press.
7. Jadhav and Bhosale, **Environmental Protection and Laws** V.M.Himalaya publ.House.
8. PC Trivedi, **Biodiversity Assessment and Conservation**Agrobios publ.

Skill Enhancement Courses

Skill Enhancement Course
Biofertilizers
(Credits 2)
Lectures: 30

Unit 1: General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. **(4 lectures)**

Unit 2:*Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.*Azotobacter*: classification, characteristics – crop response to *Azotobacter*inoculum, maintenance and mass multiplication. **(8 lectures)**

Unit 3: Cyanobacteria (blue green algae), *Azolla*and *Anabaena azollae*association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla*in rice cultivation.**(4 lectures)**

Unit 4: Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield –colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants. **(8 lectures)**

Unit 5: Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. **(6 lectures)**

Suggested Readings

1. Dubey, R.C., 2005 **A Text book of Biotechnology**S.Chand& Co, New Delhi.

2. Kumaresan, V. 2005, **Biotechnology,**Saras Publications, New Delhi.

3. John Jothi Prakash, E. 2004. **Outlines of Plant Biotechnology**. Emkay Publication, NewDelhi.

4. Sathe, T.V. 2004 **Vermiculture and Organic Farming**. Daya publishers.

5. Subha Rao, N.S. 2000, **Soil Microbiology,** Oxford & IBH Publishers, New Delhi.

6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 **Bio-fertilizers and organic Farming**AktaPrakashan, Nadiad

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

Unit 1: Herbal medicines: history and scope - definition of medical terms - role of medicinalplants in Siddha systems of medicine; cultivation - harvesting - processing - storage -marketing and utilization of medicinal plants. **(6 Lectures)**

Unit 2: Pharmacognosy - systematic position;medicinal uses of the following herbs in curingvarious ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.**(6 Lectures)**

Unit 3: Phytochemistry - active principles and methods of their testing - identification andutilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withaniasomnifera*(drugs acting on nervous system), *Clerodendronphlomoides*(anti-rheumatic) and *Centella*

asiatica(memory booster). **(6 Lectures)**

Unit 4: Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation-Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites(alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds) **(8 Lectures)**

Unit 5: Medicinal plant banks micro propagation of important species (*Withaniasomnifera*,neem and tulsi- Herbal foods-future of pharmacognosy) **(4 Lectures)**

Suggested Readings

1. R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. **Glossary of Indian medicinal plants** C.S.I.R,New Delhi.

2. Kanny, Lall, Dey and Raj Bahadur, 1984. **The indigenous drugs of India,** InternationalBookDistributors.

3. Agnes Arber, 1999. **Herbal plants and Drugs** Mangal Deep Publications.

4. V.V. Sivarajan and Balachandran Indra 1994.**Ayurvedic drugs and their plant source.**Oxford IBH publishing Co.

5. Miller, Light and Miller, Bryan, 1998. **Ayurveda and Aromatherapy.**Banarsidass, Delhi.

6. Anne Green, 2000. **Principles of Ayurveda**Thomsons, London.

7. Dr.C.K.Kokate*et al.* 1999. **Pharmacognosy.** NiraliPrakashan.

Skill Enhancement Course
Nursery and Gardening
(Credits 2)

Lectures: 30

Unit 1: Nursery: definition, objectives and scope and building up of infrastructure for nursery,planning and seasonal activities - Planting - direct seeding and transplants.**(4 Lectures)**

Unit 2: Seed: Structure and types - Seed dormancy; causes and methods of breakingdormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed
production technology - seed testing and certification. **(6 Lectures)**

Unit 3: Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – greenhouse - mist chamber, shed root, shade house and glass house. **(6Lectures)**

Unit 4: Gardening: definition, objectives and scope - different types of gardening – landscapeand home gardening - parks and its components - plant materials and design – computerapplications in landscaping - Gardening operations: soil laying, manuring, watering,management of pests and diseases and harvesting. **(8 Lectures)**

Unit 5: Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study ofcultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, andcarrots - Storage and marketing procedures. **(6 Lectures)**

Suggested Readings

1. Bose T.K. & Mukherjee, D., 1972, **Gardening in India,** Oxford & IBH Publishing Co., New Delhi.

2. Sandhu, M.K., 1989, **Plant Propagation**, Wile Eastern Ltd., Bangalore, Madras.

3. Kumar, N., 1997, **Introduction to Horticulture**, Rajalakshmi Publications, Nagercoil.

4. Edmond Musser & Andres, **Fundamentals of Horticulture**, McGraw Hill Book Co.,New Delhi.

5. Agrawal, P.K. 1993, **Hand Book of Seed Technology**, Dept. of Agriculture andCooperation, National _Seed Corporation Ltd., New Delhi.

6. Janick Jules. 1979. **Horticultural Science. (3rd Ed.),** W.H. Freeman and Co., SanFrancisco, USA.

Skill Enhancement Course
Floriculture
(Credits 2)
Lectures: 30

Unit 1: Importance and scope of floriculture and landscape gardening. **(2 Lectures)**

Unit 2: Nursery Management and Routine Garden Operations: Sexual and vegetative methodsof propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading;Stopping or pinching; Defoliation; Wintering; Mulching; Topiary**(8 lectures)**

Unit 3: Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shadeand ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms andCycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.**(6 lectures)**

Unit 4:Landscaping Places of Public Importance: **(4 lectures)**

Unit5: Commercial Floriculture: Factors affecting flower production; Production and

packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation ofImportant cut flowers (Anthurium, Lilium, Carnations, Orchids). **(8 lectures)**

Unit 6:Diseases and Pests of Ornamental Plants. **(2 lectures)**

Suggested Readings

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

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

Unit 1: Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences;Definition and Scope-Ayurveda: History, origin, plants used in ayurvedic treatments, Unani: History, concept **(10 Lectures)**

Unit 2: Conservation of endangered and endemic medicinal plants. Definition: endemic andendangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacredgroves, National Parks; Ex situ conservation: Botanic Gardens, Ethnomedicinal plant.Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification,important components of a nursery, sowing, pricking, use of green house for nurseryproduction, propagation through cuttings, layering, grafting and budding.**(10 Lectures)**

Unit 3: Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to studyethnobotany; Applications of Ethnobotany, Folk medicines of ethnobotany, ethnomedicine. **(10 Lectures)**

Suggested Readings

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

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

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

Unit 1: Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity atTheecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses ofBiodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies forvaluation, Uses of plants, Uses of microbes. **(8 lectures)**

Unit 2:Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss ofecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss,**Management of Plant Biodiversity:** Organizations associated with biodiversitymanagement-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR;Biodiversity legislation and conservations, Biodiversity information management andcommunication. **(8 lectures)**

Unit 3:Conservation of Biodiversity: Conservation of genetic diversity, species diversity andecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation,Biodiversity awareness programmes, Sustainable development. **(8 lectures)**

Unit 4: Role of plants in relation to Human Welfare; a) Importance of forestry theirutilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d)Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercialimportance. Wood and its uses. **(6 lectures)**

Suggested Readings

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

Skill Enhancement Course
Ethnobotany
(Credits 2)
Lectures: 30

Unit 1: Ethnobotany (6Lectures)

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

Unit 2: Methodology of Ethnobotanical studies (6 lectures)

a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

Unit 3: Role of ethnobotany in modern Medicine (10 lectures)

Medico-ethnobotanical sources in India;Significance of the following plants in ethno botanicalpractices (along with their habitat and morphology) a) *Azadiracthaindica*b) *Ocimum sanctum*c) *Vitex negundo*. d) *Gloriosa superba*e) *Tribulus terrestris*f) *Pongamiapinnata*g) *Cassiaauriculata*h) *Indigoferatinctoria*. Role of ethnobotany in modern medicine with specialexample *Rauvolfiasepentina, Trichopuszeylanicus, Artemisia,Withania*.Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forestmanagement (participatory forest management).

Unit 4: Ethnobotany and legal aspects (8 lectures)

Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with fewexamples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Suggested Readings

1) S.K. Jain, **Manual of Ethnobotany**, Scientific Publishers, Jodhpur, 1995.

2) S.K. Jain (ed.) **Glimpses of Indian. Ethnobotny**, Oxford and I B H, New Delhi1981

3) Lone et al,.**Palaeoethnobotany**

4) S.K. Jain (ed.) 1989. **Methods and approaches in ethnobotany.** Society of ethnobotanists,Lucknow, India.

5) S.K. Jain, 1990. **Contributions of Indian ethnobotany**.Scientific publishers, Jodhpur.

6) Colton C.M. 1997. **Ethnobotany -Principles and applications**. John Wiley and sons Chichester

7) Rama Ro, N and A.N. Henry (1996). **The Ethnobotany of Eastern Ghats in Andhra Pradesh, India**.Botanical Survey of India. Howrah.

8) Rajiv K. Sinha – **Ethnobotany The Renaissance of Traditional Herbal Medicine** – INA –SHREE Publishers, Jaipur-1996

9)Faulks, P.J. 1958.**An introduction to Ethnobotany**, Moredale pub. Ltd.

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

Unit 1: Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonousmushrooms.Types of edible mushrooms available in India - *Volvariellavolvacea, Pleurotuscitrinopileatus, Agaricusbisporus*. **(5 Lectures)**

Unit 2: Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag,vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroomunit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium,sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw,sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low cost technology, Composting technology in mushroom production. **(12 Lectures)**

Unit 3: Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long termStorage (canning, pickels, papads), drying, storage in saltsolutions. Nutrition Proteins-amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.**(8 Lectures)**

Unit 4: Food Preparation; Types of foods prepared from mushroom.Research Centres, National level and Regional level.Cost benefit ratio - Marketing in India and abroad, Export
Value. **(5 lectures)**

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991)**Oyster Mushrooms**, Department of Plant Pathology, Tamil Nadu AgriculturalUniversity, Coimbatore.

2. Swaminathan, M. (1990) **Food and Nutrition**. Bappco, The Bangalore Printing andPublishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.

3. Tewari, Pankaj Kapoor, S.C., (1988). **Mushroom cultivation**, Mittal Publications,Delhi.

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

Skill Enhancement Course

Intellectual Property Rights

(Credits 2)

Lectures: 30

Unit 1: Introduction to intellectual property right (IPR) (2 lectures)

Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, someimportant examples.IPR and WTO (TRIPS, WIPO).

Unit 2 : Patents (3 Lectures)

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents,Working of patents. Infringement.

Unit 3: Copyrights (3 Lectures)

Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.

Unit4: Trademarks (3 Lectures)

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences,Domain name.

Unit 5: Geographical Indications (3 Lectures)

Objectives, Justification, International Position, Multilateral Treaties, National Level, IndianPosition.

Unit 6:Protection of Traditional Knowledge (4 Lectures)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospectingand Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, TraditionalKnowledge on the International Arena, at WTO, at National level, Traditional Knowledge, Digital Library.

Unit 7: Industrial Designs (2 Lectures)

Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Unit 8: Protection of Plant Varieties (2 Lectures)

Plant Varieties Protection-Objectives, Justification, International Position, Plant varietiesprotection in India. Rights of farmers, Breeders and Researchers.National gene bank,Benefitsharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9:Information Technology Related Intellectual Property Rights (4 Lectures)

Computer Software and Intellectual Property, Database and Data Protection, Protection ofSemi-conductor chips, Domain Name Protection

Unit 10: Biotechnology and Intellectual Property Rights. (4 Lectures)

Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept ofinventive step, Microorganisms, Moral Issues in Patenting Biotechnological inventions.

Suggested Readings

1. N.S. Gopalakrishnan & T.G. Agitha, (2009) **Principles of Intellectual Property** Eastern
Book Company, Lucknow.

2. **Kerly's Law of Trade Marks and Trade Names** (14th Edition) Thomson, Sweet &Maxweel.

3. AjitParulekar and Sarita D' Souza, (2006) **Indian Patents Law – Legal & BusinessImplications;** Macmillan India Ltd.

4. B.L.Wadehra (2000) **Law Relating to Patents**, Trade Marks, Copyright, Designs &Geographical Indications; Universal law Publishing Pvt. Ltd., India.

5. P. Narayanan (2010) **Law of Copyright and Industrial Designs**; Eastern law House, Delhi.