Proposed Syllabus and Scheme of Examination
for
B.Sc. (Honors) Botany

Under Choice Based Credit System (CBCS)

Submitted
to
Utkal University
Vani Vihar, Bhubaneswar

Board of Studies in Botany
P.G. Department of Botany
Utkal University,Vani Vihar
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Syllabus for B.Sc. (Hon's) BOTANY-2015, Choice Based Credit System (CBCS), Utkal University

SEMESTER	COURSE OPTED	COURSE NAME	Credits	Marks*	Hours of instruction
Semester-I	Ability Enhancement Compulsory Course-I	English communications	2	50	30
	Core course-I (Theory)	Microbiology and Phycology	4	75	40
	Core Course-I (Practical)	Microbiology and Phycology	2	25	20
	Core course-II (Theory)	Biomolecules and Cell Biology	4	75	40
	Core course-II (Practical)	Biomolecules and Cell Biology	2	25	20
	Generic Elective -1 (Theory)	GE-1 - Biodiversity (Microbes, Algae, Fungi & Archegoniate)	4	75	40
	Generic Elective -1 (Practical)	GE-1 - Biodiversity (Microbes, Algae, Fungi & Archegoniate)	2	25	20
		Sub-Total of Semester-I	20	350	210
Semester -II	Ability Enhancement Compulsory Course-II	Environmental Science	2	50	30
	Core course-III (Theory)	Mycology and Phytopathology	4	75	40
	Core course-III (Practical)	Mycology and Phytopathology	2	25	20
	Core course-IV (Theory)	Archegoniate	4	75	40
	Core course-IV (Practical)	Archegoniate	2	25	20
	Generic Elective -2 (Theory)	GE-2 - Plant Physiology & Metabolism	4	75	40
	Generic Elective -2 (Practical)	GE-2 - Plant Physiology & Metabolism	2	25	20
		Sub-Total of Semester-II	20	350	210
Semester-III	Core course-V (Theory)	Anatomy of Angiosperms	4	75	40
	Core course-V (Practical)	Anatomy of Angiosperms	2	25	20
	Core course-VI (Theory)	Economic Botany	4	75	40
	Core course-VI (Practical)	Economic Botany	2	25	20
	Core course-VII (Theory)	Genetics	4	75	40
	Core course-VII (Practical)	Genetics	2	25	20
	Skill Enhancement Course-1 (Any one from 1A to 1D)	SEC-1A (Biofertilizer), SEC-1B (Herbal Technology), SEC-1C (Nursery and Gardening), SEC-1D (Floriculture)	2	50	30
	Generic Elective -3 (Theory), Any One either of GE-3A or GE-3B	GE-3A - Plant Ecology & Taxonomy, GE-3B - Plant Anatomy & Embryology	4	75	40
	Generic Elective -3 (Practical), Any One either of GE-3A or GE-3B	GE-3A - Plant Ecology & Taxonomy, GE-3B-Plant Anatomy & Embryology	2	25	20
		Sub-Total of Semester-III	26	450	270

Semester-IV	Core course-VIII (Theory)	Molecular Biology	4	75	40
	Core course-VIII (Practical)	Molecular Biology	2	25	20
	Core course-IX (Theory)	Ecology	4	75	40
	Core course-IX (Practical)	Ecology	2	25	20
	Core Course- X (Theory)	Plant Systematics	4	75	40
	Core Course- X (Practical)	Plant Systematics	2	25	20
	Skill Enhancement (Any one from 1A to 1D)	SEC-2A-Medicinal Botany, SEC-2B-Plant Diversity and Human Welfare, SEC-2C-Ethnobotany, SEC-2D-Mushroom Cultivation Technology, SEC-2E-Intellectual Property Rights	2	50	30
	Generic Elective-4 (Theory) (Any one of GE-4A & GE4B)	GE-4A-Economic Botany & Plant Biotechnology, GE-4B-Environmental Biotechnology	4	75	40
	Generic Elective-4 (Practical) (As per Theory)	GE-4A-Economic Botany & Plant Biotechnology, GE-4B-Environmental Biotechnology	2	25	20
		Sub-Total of Semester-IV	26	450	270
Semester-V	Core-XI (Theory)	Reproductive Biology of Angiosperms	4	75	40
	Core course-XI (Practical)	Reproductive Biology of Angiosperms	2	25	20
	Core-XII (Theory)	Plant Physiology	4	75	40
	Core course-XII (Practical)	Plant Physiology	2	25	20
	Discipline Specific Elective - 1 (Theory) [Any one either of DSE1A or DSE1B]	DSE=1A-Analytical Techniques in Plants Sciences, DSE=1B-Bioinformatics	4	75	40
	Discipline Specific Elective - 1 (Theory) [Any one either of DSE1A or DSE1B]	DSE=1A-Analytical Techniques in Plants Sciences, DSE=1B-Bioinformatics	2	25	20
	Discpline Specific Elective - 2 (Theory) [Any one either of DSE-2A, DSE-2B & DSE-2C]	DSE-2A-Plant Breeding, DSE-2B-National Resource Management, DSE-2C-Biostatistics	4	75	40
	Discpline Specific Elective - 2 (Practical) [As per theory]	DSE-2A-Plant Breeding, DSE-2B-National Resource Management, DSE-2C-Biostatistics	2	25	20
		Sub-Total of Semester-V	24	400	240
Semester-VI	Core course-XIII (Theory)	Plant Metabolism	4	75	40
	Core course-XIII (Practical)	Plant Metabolism	2	25	20
	Core course-XIV (Theory)	Plant Biotechnology	4	75	40
	Core course-XIV (Practical)	Plant Biotechnology	2	25	20
	Discipline Specific Elective - 3 (Theory) [Any one either of DSE-3A to DSE-3D]	DSE-3A-Stress Biology, DSE-3B-Horticulture Practices & Post Harvest Technology, DSE-3C-Research Methodology, DSE-3D Industrial & Environmental Microbiology	4	75	40

	Discipline Specific Elective - 3 (Practical) [Any one as per theory]	DSE-3A-Stress Biology, DSE-3B-Horticulture Practices & Post Harvest Technology, DSE-3C-Research Methodology, DSE-3D Industrial & Environmental Microbiology	2	25	20
	Discipline Specific Elective - 4 (Practical) [Any one as per DSE-3] Dissertation	Discipline Specific Elective - 4 (Practical) [Any one as per DSE-3] Dissertation	6	100	60
		Sub-Total of Semester-V	24	400	240
		Total Semester I+II+III+IV+V +VI	140	2400	1440

*Marks – Theory -75 marks = 15 marks Mid Semester + 60 End Semester;
Theory - 50 marks = 10 marks Mid Semester + 40 marks End Semester

Core Courses

Semester-I

Core Course I: Microbiology and Phycology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	Introduction to microbial world, microbial nutrition, growth and metabolism.	**2 lectures**
	Viruses:-Discovery,physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.	**5 lectures**
Unit–II	**Bacteria: -** 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 with reference to their role in agriculture and industry (fermentation and medicine).	**5 lectures**
Unit-III	**Algae:-** General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; and methods of reproduction, classification; criteria, system of Fritsch, and evolutionary classification of Lee (only upto groups); significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar). Role of algae in the environment, agriculture, biotechnology and industry.	**6 lectures**
Unit-IV	**Cyanophyta:-** Ecology and occurrence, range of thallus organization, cell structure, heterocyst, reproduction.economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc.*	**5 lectures**
	Chlorophyta:- General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete.* Evolutionary significance of *Prochloron.*	**5 lectures**
Unit-V	**Charophyta:-** General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.	**2 lectures**
	Xanthophyta:- General characteristics; range of thallus organization; Occurrence, morphology and life-cycle of *Vaucheria.*	**3 lectures**
	Phaeophyta:- Characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Ectocarpus* and *Fucus.*	**3 lectures**
	Rhodophyta:- General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia.*	**4 lectures**

Practical (20 classes, each class of 2h)

Microbiology	1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle. 2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule. 3. Gram staining. 4. Endospore staining with malachite green using the (endospores taken from soil bacteria).
Phycology	Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), Volvox, *Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus 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. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Semester-I

Core Course II: Biomolecules and Cell Biology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Biomolecules:-** Types and significance of chemical bonds; Structure and properties of water; pH and buffers.	**2 lectures**
	Carbohydrates: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, insulin)	**3 lectures**
	Lipids: Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure and functions. Essential fatty acids. Triacyl glycerols structure, functions and properties.	**2 lectures**
	Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quarternary; Isoelectric point; Protein denaturation and biological roles of proteins.	**2 lectures**
	Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.	**4 lectures**
Unit-II	**Bioenergenetics:** Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.	**3 lectures**
	Enzymes: 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.	**4 lectures**
Unit-III	**The cell:** Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).	**2 lectures**
	Cell wall and plasma membrane: Chemistry, structure and function of Plant Cell Wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.	**3 lectures**
Unit-IV	**Cell organelles: Nucleus;** Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.	**3 lectures**
	Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.	**2 lectures**
	Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.	**2 lectures**
	Endoplasmic Reticulum, Golgi Apparatus, Lysosomes	**2 lectures**
Unit-V	**Cell division:** Eukaryotic cell cycle, different stages of mitosis and meiosis. Cell cycle, Regulation of cell cycle.	**6 lectures**

Practical (20 classes, each class of 2h)

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. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains). 6. Study of cell and its organelles with the help of electron micrographs. 7. Study the phenomenon of plasmolysis and deplasmolysis. 8. Study different stages of mitosis and meiosis using aceto carmine and aceto orcine method.

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 Churchill Livingstone.
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. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & 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 – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction to true fungi:** Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cellwall composition; Nutrition; Classification. **Chytridiomycetes:** General account	**5 lectures**
	Zygomycota: General characteristics; Ecology; Thallus organisation; Life cycle with reference to *Rhizopus*.	**4 lectures**
	Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces, Aspergillus*, *Penicillium, Alternaria* and *Neurospora, Peziza.*	**5 lectures**
Unit-II	**Basidiomycota:** General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.	**5 lectures**
	Allied Fungi: General characterises; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.	**3 lectures**
	Oomycota: General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora, Albugo.*	**4 lectures**
Unit-III	**Symbiotic associations:** Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction.Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.	**4 lectures**
Unit-IV	**Applied Mycology:** Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.	**5 Lectures**
Unit-V	**Phytopathology:** Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host- Pathogen relationships;disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, white rust of crucifers.	**5 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps). 2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides. 3. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.

	4. *Peziza*: sectioning through ascocarp. 5. *Alternaria:* Specimens/photographs and temporary mounts. 6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberryleaves; sections/ mounts of spores on wheat and permanent slides of both the hosts. 7. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown. 8. *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study throughsection/ temporary mounts and sexual structures through permanent slides. 9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs) 10. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: TMV, Fungal diseases: Early blight of potato, and White rust of crucifers.

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 Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Semester-II

Core Course IV: Archegoniate – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction:** Unifying features of archegoniates; Transition to land habit; Alternation of generations.	**2 lectures**
Unit-II	**Bryophytes:** General characteristics; Adaptations to land habit; Classification; Range of thallus organization.Classification (up to family).*Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and Funaria*; Reproduction and evolutionary trends in Riccia, Marchantia , Anthoceros and Funaria (developmental stages not included). Ecological and economic importance of bryophytes with special reference to*Sphagnum*.	**12 lectures**
Unit-III	**Pteridophytes:** General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris*.(Developmental details not to be included).Apogamy, and apospory, heterospory andseed habit, telome theory, stelar evolution.Ecological and economic importance.	**10 lectures**
Unit-IV	**Gymnosperms:** General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus, Ginkgo* and *Gnetum*. (Developmental details not to be included). Ecological and economic importance.	**8 lectures)**
Unit-V	**Fossils:** Geographical time scale, fossils and fossilization process. Morphology, anatomy and affinities of *Rhynia, Calamites, Lepidodendron, Lyginopteris* and *Cycadeoidea.*	**8 lectures**

Practical (20 classes, each class of 2h)

Practical	1. ***Riccia*** – Morphology of thallus. 2. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical sectionof thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides). 3. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata, spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide). 4. ***Pellia, Porella***- Permanent slides. 5. ***Sphagnum***- Morphology of plant, whole mount of leaf (permanent slide only). 6. ***Funaria***- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus,spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema. 7. ***Psilotum***- Study of specimen, transverse section of synangium (permanent slide). 8. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem,whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide). 9. ***Equisetum***- Morphology, transverse section of internode, longitudinal section ofstrobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent

	slide). 10. ***Pteris***- Morphology, transverse section of rachis, vertical section of sporophyll, wholemount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide). 11. ***Cycas***- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll,transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide). 12. ***Pinus***- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male andfemalecones), transverse section of Needle, transverse section of stem, longitudinal section of transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide). 13. ***Gnetum***- Morphology (stem, male & female cones), transverse section of stem, verticalsection of ovule (permanent slide) 14. **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. Vander-Poorteri 2009 Introduction to Bryophytes. COP.

Semester-III

Core Course V: Anatomy of Angiosperms – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction and scope of Plant Anatomy:** Applications in systematics, forensics and pharmacognosy**.**	**2 lectures**
	Tissues: Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements;Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation,Ergastic substances.	**5 Lectures**
Unit-II	**Stem:** Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem.	**5 Lectures**
	Leaf: Structure of dicot and monocot leaf, Kranz anatomy.	**4 Lectures**
	Root: Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescentcentre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin oflateral root.	**4 Lectures**
Unit-III	**Vascular Cambium:** Structure, function and seasonal activity of cambium; Secondary growth in root and stem.	**4 Lectures**
	Wood: Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood,tyloses; Dendrochronology.	**5 Lectures**
	Periderm: Development and composition of periderm, rhytidome and lenticels.	**3 Lectures**
Unit –IV	**Adaptive and Protective Systems** Epidermal tissue system, cuticle, epicuticular waxes, trichomes(uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation;Anatomical adaptations of xerophytes and hydrophytes.	**5 Lectures**
Unit - V	**Secretory System:** Hydathodes, cavities, lithocysts and laticifers.	**3 Lectures**

Practical (20 classes, each class of 2h)

Practical	1. Study of anatomical details through permanent slides/temporary stain mounts/macerations/ museum specimens with the help of suitable examples. 2. Apical meristem of root, shoot and vascular cambium. 3. Distribution and types of parenchyma, collenchyma and sclerenchyma. 4. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres. 5. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood. 6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres. 7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular. 8. Root: monocot, dicot, secondary growth. 9. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels. 10. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy). 11. Adaptive Anatomy: xerophytes, hydrophytes. 12. 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. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.

Semester-III

Core Course VI: Economic Botany – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Origin of Cultivated Plants:** Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversty.	**3 lectures**
Unit-II	**Cereals :** Wheat and Rice (origin, morphology, processing & uses), brief account of millets.	**3 lectures**
	Legumes: General account, importance to man and ecosystem.	**3 lectures**
	Sugars & Starches: Morphology and processing of sugarcane, roducts and by-products of sugarcane industry. Potato – morphology, propagation & uses.	**3 lectures**
Unit-III	**Spices:**Listing of important spices, their family and part used, economic importance with specialreference to fennel, saffron, clove and black pepper	**4 lectures**
	Beverages: Tea, Coffee (morphology, processing & uses)	**4 lectures**
	Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to C*inchona, Digitalis, Papaver* and*Cannabis.*	**4 lectures**
	Tobacco: Tobacco (Morphology, processing, uses and health hazards)	**2 lectures**
Unit-IV	**Oils & Fats:** General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* and Coconut (Botanical name, family & uses)	**4 lectures**
	Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.	**4 lectures**
Unit-V	**Natural Rubber:** Para-rubber: tapping, processing and uses.	**2 lectures**
	Timber plants: General account with special reference to teak and pine.	**2 Lectures**
	Fibres: Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).	**2 lectures**

Practical (20 classes, each class of 2h)

Practical	**1. Cereals**: Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests). **2. Legumes**: Soya bean, Groundnut, (habit, fruit, seed structure, micro-chemical tests). **3. Sugars & Starches**: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests). **4. Spices:** Black pepper, Fennel and Clove (habit and sections). **5. Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans). **6. Oils & Fats**: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushedseeds. **7. Essential oil-yielding plants**: Habit sketch of*Rosa*, V*etiveria, Santalum* and *Eucalyptus* (specimens/photographs). **8. Rubber**: specimen, photograph/model of tapping, samples of rubber products. **9. Drug-yielding plants**: Specimens of *Digitalis, Papaver*and*Cannabis.* **10. Tobacco**: specimen and products of Tobacco. **11. Woods:** Tectona, Pinus: Specimen, Section of young stem. **12. Fibre-yielding plants**: Cotton (specimen, whole mount of seed to show lint and fuzz;whole mount of fibre and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fibre).

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. (2003). Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Semester-III

Core Course VII: Genetics – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Mendelian genetics and its extension** Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.	**16 lectures**
Unit-II	**Extrachromosomal Inheritance:** Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast;Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium.*	**6 lectures**
Unit-III	**Linkage, crossing over and chromosome mapping:** Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.	**12 lectures**
Unit-IV	**Variation in chromosome number and structure:** Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy	**8 lectures**
	Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation.DNA repair mechanisms.	**6 lectures**
Unit-V	**Fine structure of gene:** Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.	**6 lectures**
	Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.	**6 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Meiosis through temporary squash preparation. 2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis. 3. Chromosome mapping using test cross data. 4. Pedigree analysis for dominant and recessive autosomal and sex linked traits with floral chart. 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.

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. (2012). Concepts of Genetics. Benjamin Cummings, U.S.A. 10th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Semester-IV

Core Course VIII: Molecular Biology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Nucleic acids : Carriers of genetic information:** Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment.	**4 lectures**
Unit-II	**The Structures of DNA and RNA / Genetic Material:** DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure- Organelle DNA - mitochondria and chloroplast DNA.The Nucleosome -Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.	**8 lectures**
	The replication of DNA: Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.	**6 lectures**
Unit-III	**Central dogma and genetic code:** Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNAtemplate), Genetic code (deciphering & salient features**)**	**2 lectures**
	Mechanism of Transcription: Transcription in prokaryotes; Transcription in eukaryotes	**4 lectures**
	Processing and modification of RNA: Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.	**5 lectures**
Unit-IV	**Translation (Prokaryotes and eukaryotes):** Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.	**6 lectures**
Unit-V	**Regulation of transcription in prokaryotes and eukaryotes:** Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.	**5 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Preparation of LB medium and raising *E.Coli.* 2. Isolation of genomic DNA from *E.Coli.* 3. DNA isolation and RNA estimation by orcinol method. 4. DNA estimation by diphenylamine reagent/UV Spectrophotometry. 5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication). 6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II

	through photographs. 7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments) 8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism 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). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Semester-IV

Core Course IX: Plant Ecology and Phytogeography – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction** Concept of ecology, Autoecology, Synecology, system ecology, Levels of organization. Inter-relationships between the living world and the environment, the components of environmental, concept of hydrosphere and lithospgere and dynamism, homeostasis.	**2 lectures**
Unit-II	**Soil:** Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.	**5 lectures**
	Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.	**2 lectures**
	Light, temperature, wind and fire: Variations; adaptations of plants to their variation.	**4 lectures**
Unit-III	**Biotic interactions:**	**2 lectures**
	Population ecology: Characteristics and Dynamics .Ecological Speciation	**4 lectures**
	Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.	**4 lectures**
Unit-IV	**Ecosystems:** Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.	**4 lectures**
	Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.	**5 lectures**
Unit-V	**Phytogeography:** Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.	**8 lectures**

Practical (20 classes, each class of 2h)

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 from two soil samples by rapid field tests. 4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method. 5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats. 6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources. 7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each). (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite

	(*Orobanche*) Epiphytes, Predation (Insectivorous plants). 8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed). 9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law. 10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus. 11. Field visit to familiarise students with ecology of different sites.

Suggested Readings

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

Semester-IV

Core Course X: Plant Systematics – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Plant identification, Classification, Nomenclature; Biosystematics.**	**2 lectures**
	Identification: Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access	**5 lectures**
Unit-II	**Taxonomic hierarchy:** Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).	**5 lectures**
	Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.	**5 lectures**
Unit-III	**Systematics- an interdisciplinary science:** Evidence from palynology, cytology, phytochemistry and molecular data.	**6 lectures**
	Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.	**6 lectures**
Unit-IV	**Biometrics, numerical taxonomy and cladistics:** Characters; Variations; OTUs, character weighting and coding; cluster analysis; Phenograms, cladograms (definitions and differences).	**4 lectures**
Unit-V	**Phylogeny of Angiosperms:** Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades).origin& evolution of angiosperms; co-evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).	**7 lectures**

Practical (20 classes, each class of 2h)

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, G. (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. Maheshwari, J.K. (1963). *Flora* of Delhi. CSIR, New Delhi.
5. Radford, A.E. (1986). Fundamentals of *Plant Systematics*. Harper and Row, New York.

Semester-V

Core Course XI: Reproductive Biology of Angiosperms – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction:** History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.	**2 lectures**
Unit-II	**Anther:** Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.	**2 lectures**
	Pollen biology: Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.	**5 lectures**
Unit-III	**Ovule:** Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.	**5 lectures**
	Endosperm: Types, development, structure and functions.	**3 lectures**
	Embryo: Six types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo;Unusual features; Embryo development in *Paeonia*.	**6 lectures**
Unit-IV	**Pollination and fertilization:** Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.	**4 lectures**
	Self incompatibility: Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization;Cybrids, *in vitro* fertilization.	**5 lectures**
Unit-V	**Seed:** Structure, importance and dispersal mechanisms	**3 lectures**
	Polyembryony and apomixes: Introduction; Classification; Causes and applications.	**4 lectures**
	Germline transformation: Pollen grain and ovules through pollen tube pathway method/ *Agrobacterium*/ electrofusion/floral dip/biolistic.	**4 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation. 3. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method. 4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent

	slides/specimens/photographs). 5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus. 6. Intra-ovarian pollination; Test tube pollination through photographs. 7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria. 8. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

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

Semester-V

Core Course XII: Plant Physiology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Plant water relationship:** Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.	**6 lectures**
	Translocation in the phloem: Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.	**5 lectures**
Unit-II	**Mineral nutrition:** Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.	**5 lectures**
Unit-III	**Nutrient Uptake:** Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems,proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.	**5 lectures**
Unit-IV	**Plant growth regulators:** Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene.Brassinosteroids and Jasmonic acid.	**10 lectures**
Unit-V	**Physiology of flowering:** Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.	**4 lectures**
	Phytochrome: Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.	**5 lectures**

Practical (20 classes, each class of 2h)

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 effect of wind velocity and light on the rate of transpiration in excised twig/leaf. 4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte. 5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces). 6. To study the phenomenon of seed germination (effect of light). 7. To study the induction of amylase activity in germinating barley grains. **Demonstration experiments** 1. To demonstrate suction due to transpiration. 2. Fruit ripening/Rooting from cuttings (Demonstration). 3. Bolting experiment/*Avena* coleptile bioassay (demonstration).

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. Narosa Publishing House, New Delhi.

Semester-VI

Core Course XIII: Plant Metabolism – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Concept of metabolism:** Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric ,covalent modulation and Isozymes).	**5 lectures**
	Unit 3: Carbohydrate metabolism: Synthesis and catabolism of sucrose and starch.	**1 lectures**
Unit-II	**Carbon assimilation:** Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO2 reduction, photorespiration, C4pathways; Crassulacean acid metabolism; Factors affecting CO2 reduction.	**10 lectures**
Unit-III	**Carbon Oxidation:** Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle,amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.	**6 lectures**
	ATP-Synthesis: Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.	**4 lectures**
Unit-IV	**Lipid metabolism:** Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.	**5 lectures**
Unit-V	**Nitrogen metabolism:** Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.	**5 lectures**
	Mechanisms of signal transduction: Calcium, phospholipids, cGMP, NO.	**4 lectures**

Practical (20 classes, each class of 2h)

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

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.

Semester-VI

Core Course XIV: Plant Biotechnology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Plant Tissue Culture:** Historical perspective; Aseptic tissueculture techniques, Composition of media; Nutrient and hormone requirements (role of vitamins and hormones).	**3 lectures**
Unit-II	Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).	**7 lectures**
Unit-III	**Recombinant DNA technology-I:** Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC, MAC, HAC).Gene Cloning (Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning).	**10 lectures**
Unit-IV	**Recombinant DNA technology-II:** Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain geneof interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer-*Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics–selectable marker and reporter genes (Luciferase, GUS, GFP).	**10 lectures**
Unit-V	**Applications of Biotechnology:** Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.	**10 lectures**

Practical (20 classes, each class of 2h)

Practical	1. (a) Preparation of MS medium. (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc. 2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs. 3. Isolation of protoplasts. 4. Construction of restriction map of circular and linear DNA from the data provided. 5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment. 6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs. 7. Isolation of plasmid DNA. 8. Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Readings

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

Discipline Specific Elective Courses

Semester-V

Discipline Specific Elective (DSE –1A):
Analytical Techniques in Plant Sciences – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Imaging and related techniques:** Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.	**10 lectures**
Unit-II	**Cell fractionation:** Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2gradient, analytical centrifugation, ultracentrifugation, marker enzymes.	**5 lectures**
Unit-III	**Radioisotopes:** Use in biological research, auto-radiography, pulse chase experiment.	**3 lectures**
	Spectrophotometry: Principle and its application in biological research.	**3 lectures**
	Chromatography: Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.	**6 lectures**
Unit-IV	**Characterization of proteins and nucleic acids:** Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE	**5 lectures**
Unit-V	**Biostatistics:** Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.	**8 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs. 2. Demonstration of ELISA. 3. To separate nitrogenous bases by paper chromatography. 4. To separate sugars by thin layer chromatography. 5. Isolation of chloroplasts by differential centrifugation.

	6. To separate chloroplast pigments by column chromatography. 7. To estimate protein concentration through Lowry's methods. 8. To separate proteins using PAGE. 9. To separation DNA (marker) using AGE. 10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH). 11. Preparation of permanent slides (double staining). 12. Estimation of plant pigments.

Suggested Readings

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

Semester-V

Discipline Specific Elective (DSE –1B):
Bioinformatics – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction to Bioinformatics:** Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.	**3 Lectures**
	Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.	**4 Lectures**
Unit-II	**Biological Sequence Databases:** National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval 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, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.	**15 Lectures**
Unit-III	**Sequence Alignments:** Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).	**8 Lectures**
Unit-IV	**Molecular Phylogeny:** Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.	**5 Lectures**
Unit-V	**Applications of Bioinformatics:** Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	**5 Lectures**

Practical (20 classes, each class of 2h)

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. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. -II Edition. Benjamin Cummings.

Semester-V

Discipline Specific Elective (DSE –2A):
Plant Breeding – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Plant Breeding :** Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	**6 lectures**
Unit-II	**Methods of crop improvement:** Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.	**15 lectures**
Unit-III	**Quantitative inheritance:** Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings.Monogenic vs polygenic Inheritance.	**6 lectures**
Unit-IV	**Inbreeding depression and heterosis:** History, genetic basis of inbreeding depression and heterosis; Applications.	**6 lectures**
Unit-V	**Crop improvement and breeding:** Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.	**7 lectures**

Practical (20 classes, each class of 2h)

Practical	Practical related to theory

Suggested Readings

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

Semester-V

Discipline Specific Elective (DSE –2B):
Natural Resource Management – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

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

Practical (20 classes, each class of 2h)

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

Suggested Readings

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

Semester-V

Discipline Specific Elective (DSE –2C):
Biostatstics – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Biostatistics** - definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.	**8 lectures**
Unit-II	Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods.	**8 lectures**
Unit-III	Measures of central tendency - mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.	**10 lectures**
Unit-IV	Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.	8 **lectures**
Unit-V	Statistical inference - hypothesis - simple hypothesis - student 't' test - chi square test.	**6 lectures**

Practical (20 classes, each class of 2h)

Practical	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. Biostatistic, Danniel, W.W., 1987.New York, John Wiley Sons.
2. An introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S and Richards, J. Christian Medical College, Vellore
3. Statistical Analysis of epidemiological data, Selvin, S., 1991. New York University Press. 4. Statistics for Biology, Boston, Bishop, O.N. Houghton, Mifflin.
5. The Principles of scientific research, Freedman, P. New York, Pergamon Press.
6. Statistics for Biologists, Campbell, R.C., 1998.Cambridge University Press.

Semester-VI

Discipline Specific Elective (DSE –3A):
Stress Biology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Defining plant stress:** Acclimation and adaptation.	**2 lectures**
Unit-II	**Environmental factors:** Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.	**12 lectures**
Unit-III	**Stress sensing mechanisms in plants:** Role of nitric oxide. Calcium modulation, Phospholipid signaling	**12 lectures**
Unit-IV	**Developmental and physiological mechanisms that protect plants against environmental stress:** Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmoticadjustment; Compatible solute production.	**10 lectures**
Unit-V	**Reactive oxygen species–Production and scavenging mechanisms**.	**4 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress. 2. Superoxide activity in seedlings in the absence and presence of salt stress. 3. Assay of Ascorbate 4. Assay of peroxidase. 5. Assay of superoxide dismutase activity. 6. Quantitative estimation and analysis of catalase.

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.

Semester-VI

Discipline Specific Elective (DSE –3B):
Horticultural Practices and Post-Harvest Technology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction:** Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism.	**2 lectures**
	Ornamental plants: Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, Coral tree).	**3 lectures**
Unit-II	**Fruit and vegetable crops:**Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits).	**4 lectures**
	Horticultural techniques: Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations.	**6 lectures**
Unit-III	**Landscaping and garden design :** Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.	**4 lectures**
	Floriculture: Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.	**4 lectures**
Unit-VI	**Post-harvest technology:** Importance of post harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.	**6 lectures**
	Disease control and management : Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetable crops.	**5 lectures**
Unit-V	**Horticultural crops - conservation and management:** Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.	**6 lectures**
	Field trip: Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.	

Practical (20 classes, each class of 2h)

Practical	Practical related to theory

Suggested Readings

1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.

2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.

3. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.

4. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications, USA.

5. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.

Semester-VI

Discipline Specific Elective (DSE –3C):
Research Methodology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Basic concepts of research :**Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs emperical).Research methods vs methodology.Literature-review and its consolidation; Library research; field research; laboratory research.	**6 lectures**
	General laboratory practices: Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases.Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.	**8 lectures**
Unit-II	**Data collection and documentation of observations:** Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissuespecimens and application of scale bars. The art of field photography.	**4 lectures**
	Overview of Biological Problems : History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.	**4 lectures**
Unit-III	**Methods to study plant cell/tissue structure:** Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.	**4 lectures**
Unit-VI	**Plant microtechniques :** Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.	**8 lectures**
Unit-V	**The art of scientific writing and its presentation :** Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power point presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.	**6 lectures**

Practical (20 classes, each class of 2h)

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, New York, U.S.A.

Semester-VI

Discipline Specific Elective (DSE –3D):
Industrial and Environmental Microbiology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Scope of microbes in industry and environment:**	**2 lectures**
	Bioreactors/Fermenters and fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.	**8 lectures**
Unit-II	**Microbial production of industrial products:** Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)	**8 lectures**
	Microbial enzymes of industrial interest and enzyme immobilization: Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**).**	**6 lectures**
Unit-III	**Microbes and quality of environment:** Distribution of microbes in air; Isolation of microorganisms from soil, air and water.	**4 lectures**
Unit-IV	**Microbial flora of water:** Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.	**6 lectures**
Unit-V	**Microbes in agriculture and remediation of contaminated soils:** Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.	**6 lectures**

Practical (20 classes, each class of 2h)

Practical	1.Principles and functioning of instruments in microbiology laboratory 2.Hands on sterilization techniques and preparation of culture media.

Suggested Readings

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

Generic Elective Courses

Semester-III

Generic Elective (GE –1A):
Biodiversity (Microbes, Algae, Fungi and Archegoniate) – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Microbes :** Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.	**8 lectures**
Unit-II	**Algae:** General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*,*Chlamydomonas, Oedogonium*, *Vaucheria, Fucus, Polysiphonia*. Economic importance of algae.	**10 lectures**
	Fungi : Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium,Alternaria* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations-Lichens:	**6 lectures**
Unit-III	**Introduction to Archegoniate :** Unifying features of archegoniates, Transition to land habit, Alternation of generations.	**2 lectures**
	Bryophytes : General characteristics, adaptations to land habit, Classification, Range of thallus organization.Classification (up to family), morphology, anatomy and reproduction of *Marchantia* and *Funaria*.(Developmental details not to be included).Ecology and economic importance of bryophytes with special mention of *Sphagnum*.	**6 lectures**
Unit-IV	**Pteridophytes :** General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*.(Developmental details not to be included).Heterospory and seed habit, stellar evolution.Ecological and economical importance of Pteridophytes.	**5 lectures**
Unit-V	**Gymnosperms:** General characteristics, classification.Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus*. (Developmental details not to be included).Ecological and economical importance.	**6 lectures**

Practical (20 classes, each class of 2h)

Practical	1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. 2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.

	3. Gram staining 4. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), *Oedogonium, Vaucheria, Fucus* and Polysiphonia* through temporary preparations and permanent slides. (* *Fucus* - Specimen and permanent slides) 5. *Rhizopus and Penicillium*: Asexual stage from temporary mounts and sexual structuresthrough permanent slides. 6. *Alternaria:* Specimens/photographs and tease mounts. 7. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberryleaves; section/tease mounts of spores on Wheat and permanent slides of both the 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 throughgemma cup, 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 (permanent slide). 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 (permanent slide). 15. ***Pteris***- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores(temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide). 16. ***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). 17. ***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, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

Semester-III

Generic Elective (GE –3B):
Plant Ecology and Taxonomy – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Introduction:**	**2 lectures**
	Ecological factors : Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes	**6 lectures**
	Plant communities : Characters; Ecotone and edge effect; Succession; Processes and types	**3 lectures**
Unit-II	**Ecosystem :** Structure; Biotic and abiotic components, energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous	**6 lectures**
	Phytogeography : Principle biogeographical zones; Endemism	**2 lectures**
Unit-III	**Introduction to plant taxonomy:** Identification, Classification, Nomenclature.	**2 lectures**
	Identification : Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	**3 lectures**
Unit-IV	**Taxonomic evidences from palynology, cytology, phytochemistry and molecular Data**:	**4 lectures**
	Taxonomic hierarchy: Ranks, categories and taxonomic groups	**2 lectures**
	Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	**5 lectures**
Unit-V	**Botanical nomenclature:** Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	**4 lectures**
	Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).	**5 lectures**

Practical (20 classes, each class of 2h)

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, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test. 3. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats. 4. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each). (b)Study of biotic interactions of the following: Stem parasite (*Cuscuta)*, Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants) 5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed) 6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and

	comparison with Raunkiaer's frequency distribution law 7. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae - *Brassica,Alyssum / Iberis;* Asteraceae -*Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax;* Solanaceae -*Solanum nigrum, Withania;* Lamiaceae -*Salvia, Ocimum*; Liliaceae - *Asphodelus / Lilium / Allium.* *8.* Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

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

Semester-II

Generic Elective (GE –2):
Plant physiology and Metabolism – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

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

Practical (20 classes, each class of 2h)

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

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.

Semester-IV

Generic Elective (GE –4A):
Economic Plant Anatomy and Embryology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Plant-water relations:** Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.	**4 lectures**
	Mineral nutrition: Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.	**4 lectures**
	Translocation in phloem.: Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading	4 **lectures**
Unit-II	**Photosynthesis:** Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.	**8 lectures**
Unit-III	**Respiration :** Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.	**4 lectures**
Unit-IV	**Enzymes:** Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.	**3 lectures**
	Nitrogen metabolism : Biological nitrogen fixation; Nitrate and ammonia assimilation.	**3 lectures**
Unit-V	**Plant growth regulators :**Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.	**5 lectures**
	Plant response to light and temperature: Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.	**5 lectures**

Practical (20 classes, each class of 2h)

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 by excised twig. 3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte. 4. Demonstration of Hill reaction. 5. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration. 6. To study the effect of light intensity and bicarbonate concentration on O2 evolution in photosynthesis. 7. Comparison of the rate of respiration in any two parts of a plant. 8. Separation of amino acids by paper chromatography. **Demonstration experiments (any four)** 1. Bolting. 2. Effect of auxins on rooting. 3. Suction due to transpiration. 4. R.Q. 5. Respiration in roots.

Suggested Readings

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

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

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

Semester-IV

Generic Elective (GE –4B):
Botany and Plant Biotechnology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	**Origin of Cultivated Plants:** Concept of centres of origin, their importance with reference to Vavilov's work.	**3 lectures**
Unit-II	**Cereals:** Wheat -Origin, morphology, uses	**3 lectures**
	Legumes : General account with special reference to Gram and soybean	**4 lectures**
Unit-III	**Spices :** General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	**4 lectures**
	Beverages: Tea (morphology, processing, uses)	**3 lectures**
Unit-IV	**Oils and Fats :** General description with special reference to groundnut	**3 lectures**
	Fibre Yielding Plants: General description with special reference to Cotton (Botanical name, family, part used,morphology and uses)	**3 lectures**
Unit-V	**Introduction to biotechnology**	**2 lectures**
	Plant tissue culture: Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications, Gene cloning by recombinant DNA technology, transgenic plants.	**6 lectures**
	Molecular Techniques: Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection.Molecular diagnosis of human disease, Human gene Therapy.	**9 lectures**

Practical (20 classes, each class of 2h)

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

Suggested Readings

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
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 and Applications of recombinant DNA. ASM Press, Washington.

Semester-I/II

Generic Elective (GE –V):
Environmental Biotechnology – 100 marks
(Credits-6: Theory-4, Practical-2)
THEORY (Each class 1 hour): PRACTICAL (Each class 2 hours)
[75 marks (Mid Sem 15 + End Sem 60)]
Lectures: 60 [40 Theory + 20 Practical classes]

Unit-I	Environment - basic concepts and issues, global environmental problems – ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.	**4 lectures**
	An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, Bioconcentration, bio/geomagnification.	**4 lectures**
Unit-II	Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.	**6 lectures**
Unit-III	Xenobiotic compounds - organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation.	**6 lectures**
	Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.	**4 lectures**
Unit-IV	Sustainable Development: Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.	**6 lectures**
Unit-V	International Legislations, Policies for Environmental Protection: Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.	**3 lectures**
	National Legislations, Policies for Pollution Management: 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, Central and State Pollution Control Boards: Constitution and power.	**3 lectures**
	Public Participation for Environmental Protection: Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.	**4 lectures**

Practical (20 classes, each class of 2h)

Practical	1. Water/Soil analysis - DO, salinity, pH, chloride, total hardness, alkalinity, acidity, nitrate, calcium, Magnesium and phosphorus. 2. Gravimetric analysis-Total solid, dissolved solid, suspended solid in an effluent 3. Microbial assessment of air (open plate and air sample) and water

Suggested Readings

1. Waste water engineering - treatment, disposal and reuse, Metcalf and Eddy Inc., Tata McGraw Hill, New Delhi.
2. Environmental Chemistry, AK. De, Wiley Eastern Ltd, New Delhi.
3. Introduction to Biodeterioration, D.Allsopp and K.J. Seal, ELBS / Edward Arnold.
4. Bioremidation, Baaker, KH and Herson D.S., 1994. Mc.GrawHill Inc, NewYork.
5. Industrial and Environmental Biotechnology - Nuzhat Ahmed, Fouad M. Qureshi and Obaid Y. Khan, 2006. Horizon Press.
6. Environmental Molecular Biology, Paul. A, Rochelle, 2001.Horizon Press.
7. Environmental Protection and Laws by Jadhav and Bhosale, V.M.Himalaya publ. House 13. Biodiversity Assessment and Conservation by PC Trivedi, Agrobios publ.

Semester-III

Skill Enhancement Courses (SEC –I):
Biofertilizers – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	**4 lectures**
Unit-II	*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-III	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-IV	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-V	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, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New _Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic _Farming Akta Prakashan, Nadiad

Semester-III

Skill Enhancement Courses (SEC –II):
Herbal Technology – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.	**6 lectures**
Unit-II	Pharmacognosy - systematic position m edicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.	**6 lectures**
Unit-III	Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).	**6 lectures**
Unit-IV	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-V	Medicinal plant banks micro propagation of important species (*Withania somnifera*, neem and tulsi- Herbal foods-future of pharmacognosy)	**4 lectures**

Suggested Readings

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

Semester-III

Skill Enhancement Courses (SEC –III):
Nursery and Gardening – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.	**4 lectures**
Unit-II	Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification.	**6 lectures**
Unit-III	Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house - mist chamber, shed root, shade house and glass house.	**6 lectures**
Unit-IV	Gardening: definition, objectives and scope - different types of gardening – landscape and home gardening - parks and its components - plant materials and design – computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.	**8 lectures**
Unit-V	Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - 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 and Cooperation, National _Seed Corporation Ltd., New Delhi.
6. Janick Jules. 1979. Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.

Semester-III

Skill Enhancement Courses (SEC –IV):
Floriculture – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.	**2 lectures**
Unit-II	Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators.	**8 lectures**
Unit-III	Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.	**4 lectures**
Unit-IV	Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India	**4 lectures**
	Landscaping Places of Public Importance: Landscaping highways and Educational institutions.	**4 lectures**
Unit-V	Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids).	**6 lectures**
	Diseases and Pests of Ornamental Plants.	**2 lectures**

Suggested Readings

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

Semester-IV

Skill Enhancement Courses (SEC –V):
Medical Botany – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definitionand Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments.	**5 lectures**
Unit-II	Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.	**5 lectures**
Unit-III	Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; *Ex situ* conservation: Botanic Gardens, Ethnomedicinal plant Gardens.	**6 lectures**
Unit-IV	Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.	**6 lectures**
Unit-V	Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. Folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.	**8 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.

Semester-IV

Skill Enhancement Courses (SEC –VI):
Plant Diversity and Human Welfare – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at theecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	**6 lectures**
Unit-II	**Loss of Biodiversity:** Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss,	**6 lectures**
Unit-III	**Management of Plant Biodiversity:** Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.	**6 lectures**
Unit-IV	**Conservation of Biodiversity:** Conservation of genetic diversity, speciesdiversity and ecosystem diversity, *In situ* and *ex situ* conservation, Socialapproaches to conservation, Biodiversity awareness programmes, Sustainable development.	**6 lectures**
Unit-V	**Role of plants in relation to Human Welfare**; a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.	**6 lectures**

Suggested Readings

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

Semester-IV

Skill Enhancement Courses (SEC –VII):
Ethnobotany – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.	**6 lectures**
Unit-II	**Methodology of Ethnobotanical studies** a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.	**6 lectures**
Unit-III	**Role of ethnobotany in modern Medicine** Medico-ethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Vitex negundo*. d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia, Withania*.	**8 lectures**
Unit-IV	Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).	**4 lectures**
Unit-V	**Ethnobotany and legal aspects** Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.	**6 lectures**

Suggested Readings

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

2) S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi – 1981

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 ethnobotny.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.

Semester-IV

Skill Enhancement Courses (SEC –VIII):
Mushroom Culture Technology – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms.Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.	**5 lectures**
Unit-II	Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag.	**6 Lectures**
Unit-III	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.	**6 lectures**
Unit-IV	Storage and nutrition : Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in saltsolutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.	**8 lectures**
Unit-V	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 Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

Semester-IV

Skill Enhancement Courses (SEC –IX):
Intellectual Property Rights – 50 marks
(Credits-2: Lectures: 30)
THEORY (Each class 1 hour)
[50 marks (Mid Sem 10 + End Sem 40)]

Unit-I	**Introduction to intellectual property right (IPR) :** Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).	**2 lectures**
	Patents: Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement.	**3 Lectures**
	Copyrights: Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.	**3 Lectures**
Unit-II	**Trademarks:** Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name.	**3 Lectures**
	Geographical Indications : Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.	**3 Lectures**
Unit-III	**Protection of Traditional Knowledge :** Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.	**4 Lectures**
Unit-IV	**Protection of Plant Varieties :** Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers.National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.	**2 Lectures**
Unit-V	**Industrial Designs:** Objectives, Rights, Assignments, Infringements, Defences of Design Infringement	**2 Lectures**