STATE MODEL SYLLABUS FOR UNDERGRADUATE COURSE IN BOTANY
(Bachelor of Science Examination)

UNDER
CHOICE BASED CREDIT SYSTEM

Course Structure of U.G. Botany Honours				
Semester	**Course**	**Course Name**	**Credit**	**Total marks**
Semester-I	AECC-I		4	100
	C-1 (Theory)	Microbiology andPhycology	4	75
	C-1 (Practical)	Microbiology andPhycology	2	25
	C-2 (Theory)	Biomolecules and CellBiology	4	75
	C-2 (Practical)	Biomolecules and CellBiology	2	25
	GE -1A (Theory)	Biodiversity (Microbes,Algae, Fungi & Archegoniate)	4	75
	GE -1A(Practical)	Biodiversity (Microbes,Algae, Fungi & Archegoniate)	2	25
Semester-II	AECC-II		4	100
	C-3 (Theory)	Mycology and Phytopathology	4	75
	C-3 (Practical)	Mycology and Phytopathology	2	25
	C-4 (Theory)	Archegoniate	4	75
	C-4 (Practical)	Archegoniate	2	25
	GE -2A (Theory)	Plant Physiology & Metabolism	4	75
	GE -2A(Practical)	Plant Physiology & Metabolism	2	25
Semester-III	C-5 (Theory)	Anatomy of Angiosperms	4	75
	C-5 (Practical)	Anatomy of Angiosperms	2	25
	C-6 (Theory)	Economic Botany	4	75
	C-6 (Practical)	Economic Botany	2	25
	C-7 (Theory)	Genetics	4	75
	C-7 (Practical)	Genetics	2	25
	SEC-1		4	100
	GE -1B (Theory)	Plant Ecology & Taxonomy	4	75
	GE -1B (Practical)	Plant Ecology & Taxonomy	2	25
Semester-IV	C-8 (Theory)	Molecular Biology	4	75
	C-8 (Practical)	Molecular Biology	2	25
	C-9 (Theory)	Plant Ecology & Phytogeography	4	75
	C-9 (Practical)	Plant Ecology & Phytogeography	2	25
	C-10 (Theory)	Plant Systematics	4	75
	C-10 (Practical)	Plant Systematics	2	25
	SEC II		4	100
	GE-2B (Theory)	Plant Anatomy,Embryology & Biotechnology	4	75
	GE-2B(Practical)	Plant Anatomy,Embryology & Biotechnology	2	25
	C-11 (Theory)	Reproductive Biology ofAngiosperms	4	75
	C-11 (Practical)	Reproductive Biology ofAngiosperms	2	25
	C-12 (Theory)	Plant Physiology	4	75

Semester-V	C-12 (Practical)	Plant Physiology	2	25
	DSE - 1 (Theory)	Analytical Techniques inPlants Sciences	4	75
	DSE - 1 (Practical)	Analytical Techniques inPlants Sciences	2	25
	DSE - 2 (Theory)	Natural ResourceManagement	4	75
	DSE - 2 (Practical)	Natural Resource Management	2	25
Semester-VI	C-13 (Theory)	Plant Metabolism	4	75
	C-13 (Practical)	Plant Metabolism	2	25
	C-14 (Theory)	Plant Biotechnology	4	75
	C-14 (Practical)	Plant Biotechnology	2	25
	DSE - 3 (Theory)	Horticulture Practices &Post Harvest Technology	4	75
	DSE-3 (Practical)	Horticulture Practices & Post Harvest Technology	2	25
	DSE – 4 Project work	Project Work	6	100
		Total	**148**	**2600**

BOTANY

HONOURS PAPERS:
Core course – 14 papers
Discipline Specific Elective – 4 papers
Generic Elective for non-Botany students – 4 papers. In case University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper. The students have the option of taking any two.

Marks per paper – Mid-term: 15 marks, End term: 60 marks (Theory) + 25 marks (Practical),Total – 100 marks
Credit per paper – 6
Teaching hours per paper – 40 hours (theory) + 10 hours (practical)

Value Added and Add On Course (Optional), Total Course duration- 30 hours

Semester	**Course**	**Course Title**	**Marks**
Value Added Course (Optional)			
Any Semester	VA- I	Protein Separation Techniques	50
Any Semester	VA-II	Microbes And Environment	50
Any Semester	VA III	Biodiversity And Conservation	50
Add On Course (Optional)			
Any Semester	AO-I	Statistics In Biology	50
Any Semester	AO-II	Secondary Metabolites of Plants	50
Any Semester	AO-III	Development Of Transgenic Plants	50

Core Paper I

MICROBIOLOGY AND PHYCOLOGY

Objectives:

1. To introduce the amazing group of microorganisms which are intricately associated with human and other living organisms.
2. To learn the discovery, nature and multiplication of virus particles.
3. To know the characteristics, growth and physiology of bacteria and their role in agriculture, health and industry.
4. To learn the general characteristics and ecological distribution of bacteria, algae and cyanobacteria and their immense importance to the mankind.
5. To have knowledge about the habitats, distribution and diversity of algae in the soil, freshwater and marine environments.

Outcomes:

On completion of the course

1. The students would be able to understand the diverse nature of microbes and their interaction with other organisms.
2. The students certainly get the opportunities to learn the basics of the nature and impact of viruses.
3. The students shall be able to understand the potential of various microbes and the approaches to use them for human welfare.
4. The students would be able to identify the important microbes including bacteria, cyanobacteria, and algae available in local environments and understand their beneficial roles.
5. The students shall learn about the immense potential the algal resources and understand the methods of cultivation and use of algae.

Unit-I

Introduction to microbial world, microbial nutrition, growth and metabolism. **Viruses:** Discovery, physicochemical 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.

Unit–II

(i) 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).

(ii) Cyanobacteria:- Ecology and occurrence, cell structure, heterocyst, reproduction, economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc*. General characteristics of prochlorophyceae, Evolutionary significance of Prochloron.

Unit–III

(i) 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); Role of algae in the environment, agriculture, biotechnology and industry.

(ii) Chlorophyta:- General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium* and *Coleochaete*.

Unit-IV

(i) Charophyta:- General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.

(ii) Xanthophyta:- General characteristics; Occurrence, morphology and life- cycle of *Vaucheria*.

(iii) Phaeophyta:-Characteristics, occurrence, cell structure and reproduction.Morphology and life-cycles of *Ectocarpus* and *Fucus*.

(iv) Rhodophyta:-General characteristics, occurrence, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia*.

PRACTICAL

Microbiology

(i) Electron micrographs/Models of viruses –T-Phage and TMV, Line drawings/Photographs of Lytic and Lysogenic Cycle.

(ii) Types of Bacteria to be observed from temporary/permanent slides/photographs.

(iii)Examination of bacteria from bacterial culture by Gram's staining method.

(iv)Electron micrographs of bacteria, binary fission, endospore, conjugation, rootNodule (live materials and photographs).

Phycology

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

Text Books:

1. Singh, V., Pandey, P.C., and Jain, D.K. (2017). Microbiology and Phycology,Rastogi Publication, Meerut.

Reference Books:

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Prescott, L.M., Harley J.P., Klein D. A. (2010). Microbiology, McGraw-Hill, India.8th edition.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. 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.
5. Pelczar, M.J., Chan, E.C.S., Krieg, N.R. (2011) Microbiology, 8th edition, TataMcGraw-Hill Co, New Delhi.
6. Willey, Sherwood and Christopher. Laboratory exercises in Microbiology. McGraw-Hill, India. 9th edition.
7. Vasistha B.R. (2017) Botany for Degree student, Algae, S. Chand Publication, NewDelhi.
8. Mishra B. K. (2018) Microbiology and Phycology, Kalyani Publishers, New Delhi.

Core Paper II
BIOMOLECULES AND CELL BIOLOGY

Objectives:

1. To know about the chemical bonds and energetic of cellular processes and the role of enzymes in cellular reactions.
2. To understand the basic components of prokaryotic and eukaryotic cells and the role of various macromolecules in the cells.
3. To have an understanding on nucleic acids as the genetic material;
4. To learn the basic mechanism of replication of nucleic acids
5. Understand how cells undergo mitosis & meiosis

Outcomes:

On completion of the course

1. Students will understand the importance of energy for cellular processes.
2. Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
3. Students will understand how these cellular components are used to generate and utilize energy in cells.
4. Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes.
5. Students will understand the cellular components underlying mitotic and meiotic cell division.

Unit-I

(i) Biomolecules and Bioenergetics: Types and significance of chemical bonds; Structure and properties of water; pH and buffers. Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions.

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

(iii) Carbohydrates: Nomenclature, classification, structure and function of Monosaccharides, Disaccharides, Oligosaccharides and polysaccharides

Unit –II

(i) Lipids: Definition and major classes of storage and structural lipids. Fatty acid structure and functions. Essential fatty acids. Triacyl glycerol structure, functions andproperties.

(ii) Proteins: Structure and classification of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quaternary; Isoelectric point; Protein denaturation and biological roles of proteins.

(iii) 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.

Unit –III

(i) The Cell: Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic

cells; Origin of eukaryotic cell (Endosymbiotic theory).

(ii) 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.

(iii) Cell organelles: Nucleus; Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

Unit-IV

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

(ii) Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Endoplasmic Reticulum, Golgi Apparatus, Lysosomes.

(iii) Cell division: Eukaryotic cell cycle, different stages of mitosis and meiosis. Cell cycle, Regulation of cell cycle.

PRACTICAL

(i) Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.

(ii) Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*

(iii) Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. (iv)Counting the cells per unit volume with the help of hemocytometer. (Yeast/pollen grains).

(v) Study the phenomenon of plasmolysis and deplasmolysis.

(vi) Study of different stages of mitosis and meiosis using aceto carmine and aceto orcine method from Onion root tip and bud respectively.

Text Books:

1. Rastogi, V. B. (2016). Introductory Cytology, Kedar Nath & Ram Nath, Meerut
2. Gupta, P. K. (2017). Biomolecules and Cell Biology, Rastogi Publication, Meerut.

Reference Books:

1. Sahoo, K. (2017) Biomolecules and Cell Biology, Kalyani Publishers, New Delhi.
2. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman
3. Nelson, D.L. and Cox, M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.
4. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition.ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
5. 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

Core Paper III
MYCOLOGY AND PHYTOPATHOLOGY

Objectives:

1. To learn classification and diversity of fungi and their nutritional requirements.
2. To learn the life cycle and ecology of some important genera of fungi and their pathogenicity.
3. To understand the beneficial fungal interactions.
4. To learn about edible fungi and their role in human nutrition.
5. To learn the beneficial application of fungi in agriculture and medicine.
6. To know the phytopathological processes and the method of their prevention and control.

Outcomes:

On completion of the course the students shall be able to

1. Have an idea on the vast fungal diversity in nature and method of their identification and culture.
2. Know the life cycle of commonly occurring fungal genera and the disease caused by them.
3. Have knowledge on the types of fungal associations and their importance.
4. Have knowledge and skill on the application of fungi and fungal biomolecules in human welfare.
5. Have skill to understand the host - parasite relationship and its role in establishment of viral, fungal and bacterial diseases in plants.
6. Understand the causes and conditions for commonly occurring plant diseases and the methods of their control.

Unit-I

(i) Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification.

(ii) Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

(iii) Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces, Aspergillus, Penicillium,* and *Neurospora.*

(iv) Basidiomycota: General characteristics; Ecology and Classification; Life cycle of *Puccinia* and *Agaricus*.

Unit-II

(i) Allied Fungi: General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

(i) Oomycota: General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora*, and *Albugo.*

(ii) 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. Economic importance of Lichens.

Unit-III

Applied Mycology: Role of fungi in biotechnology, Mushroom cultivation, Application of fungi in food industry (Flavor & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control

(Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit-IV

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, Vein Clearing. Fungal diseases – Early blight of potato, Loose and covered smut.

PRACTICAL

(i) Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium,ascocarps & basidiocarps).

(ii) *Rhizopus*: study of asexual stage from temporary mounts and sexual structuresthrough permanent slides.

(iii) *Aspergillus, Penicillium* and *Saccharomyces*: study of asexual stage fromtemporary mounts. Study of Sexual stage from permanent slides/photographs.

(iv) *Puccnia :* Study of different stages from temporary mounts and permanent slides.

(v) *Agaricus*: Specimens of button stage and full-grown mushroom; sectioning of gills of *Agaricus*, and fairy rings are to be shown.

(vi) *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.

(vii) *Phytopathology*: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: Mosaic disease of ladies' finger, papaya, cucurbits, moong, black gram, Fungal diseases: Blast of rice, Tikka disease of ground nut, powdery mildew of locally available plants and White rust of crucifers.

Text Books:

1. Mishra, B. K. (2017), Mycology and Phytopathology, Kalynai Publishers, NewDelhi.

Reference Books:

1. Sharma, P. D. (2017). Mycology and Phytopathology Rastogi Publication, Meerut.
2. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, JohnWiley &Sons (Asia) Singapore. 4th edition.
4. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press,Cambridge. 3rd edition.
5. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacmillanPublishers India Ltd.
6. Mehrotra, R. S. (2011). Plant Pathology. Tata Mc Graw-Hill Publishing CompanyLimited, New Delhi

Core Paper IV
ARCHEGONIATAE

Objectives:

1. To know the principles, hypotheses and process of adaptation of plants to land habitat.
2. To learn about the origin classification, and characteristics of bryophytes through some representative genera.
3. To learn about the origin and distribution of vascular plants and stages of evolution of conducting tissues.
4. To study the morphology, and characteristics of pteridophytes through some representative genera.
5. To learn the characteristics, classification and importance of the gymnosperms.
6. To have a general knowledge on the fossils and fossilization processes.

Outcomes:

On completions of the course the students shall

1. Able to understand the mechanism of the evolution of the higher plants and their adaptation to land habit.
2. Knowledge on the diversity of archegoniates and their and their pattern of habitat specific distribution.
3. Knowledge on the characteristics of bryophytes and skill to differentiate the genera on the basis of their morphology and anatomy.
4. Ability to identify the members of pteridophytes and knowledge on their characteristic features.
5. Understand the unique features and distribution of gymnosperms.
6. Capacity to analyze various types of fossils on the basis of their characters.

Unit-I

(i) Introduction: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Origin of land plants and Adaptations to land habit;

(ii) Bryophytes: Origin and Classification; Range of thallus organization. Classification (up to family). Structure, Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes.

Unit-II

Pteridophytes: General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*. Apogamy, and apospory, heterospory and seed habit, telome theory, stellar evolution and economic importance.

Unit-III

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.

Unit-IV

Palaeobotany: Geological time scale, fossils and fossilization process. Morphology, anatomy and affinities of Rhynia, Calamites, Lepidodendron, Lyginopteris, Cycadeoidea and Williamsonnia.

PRACTICAL

(i) Morphology, anatomy and reproductive structures of *Riccia, Marchantia, Anthoceros,Funaria*.
(ii) *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
(iii) *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).
(iv) *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
(v) Study of temporary preparations and permanent slides of *Marsilea*.
(vi) *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
(vii) *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll and megaspore, T.S root, leaflet, rachis
(viii) *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), T.S. Needle, stem, L.S. male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), L.S. of female cone.
(ix) *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide).
(x) Study of some fossil slides / photographs as per theory.

Text Books:

1. Vasistha, B. R. (2017) Botany for Degree student, Bryophyta, S. Chand Publication, NewDelhi.
2. Singh, V., Pandey, P.C. and Jain, D.K. (2017). Archegoniate, Rastogi Publication,Meerut.

Reference Books:

1. Acharya, B. S. (2017), Archegoniate, Kalyani Publishers, New Delhi.
2. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. New Delhi,India.
3. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.

Core Paper V
ANATOMY OF ANGIOSPERMS

Objectives:

This paper emphasizes on the internal structure of plants and plant parts. The objectives are

1. To explain the tissues and tissue systems in plants.
2. To explain the organization of shoot and root apices.
3. To educate the students on the activity of meristems for primary and secondary growth of plants
4. To explain about various types of woods in plants and their developmental pattern.

Outcomes:

After the completion of the course the students shall have

1. The ability to examine the internal anatomy of plant systems and organs.
2. Develop a critical understanding of the evolution of the concept of organization of shoot and root apex.
3. Analyze the composition of different parts of plants and their relationships.
4. Evaluate the adaptive and protective morphological systems of plants.

Unit-I

(i) Introduction and scope of Plant Anatomy: Applications in systematics, forensics and pharmacognosy.

(ii) Tissues: Classification of tissues; Simple and complex tissues (no phylogeny); cyto- differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Cell wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.

Unit-II

(i) Stem: Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Anatomy of dicot and monocot stem. Vascular Cambium: Structure, function and seasonal activity of cambium; secondary growth in stem(normal and anomalous). Root Stem transition.

(ii) Leaf: Anatomy of dicot and monocot leaf, Kranz anatomy.

Unit-III

(i) Root: Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent center; Root cap; Anatomy of dicot and monocot root; Endodermis, exodermis and origin of lateral root. Secondary growth in roots.

(ii) 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.

(iii) Periderm: Development and composition of periderm, rhytidome and lenticels.

Unit –IV

(i) Adaptive and Protective Systems Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular: two examples of each), stomata (classification); Anatomical adaptations of xerophytes and hydrophytes.

(ii) Secretory System: Hydathodes, cavities, lithocysts and laticifers.

(iii) Mechanical tissue system.

PRACTICAL

1. Study of distribution and types of parenchyma, collenchyma and sclerenchyma, Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres, Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
2. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
3. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
4. Root: monocot, dicot, secondary growth.
5. Stem: monocot, dicot - primary and secondary growth (normal and anomalous); periderm; lenticels.
6. Leaf: isobilateral, dorsiventral, C_4 leaves (Kranz anatomy).
7. Ecological anatomy.

Text Books:

1. Singh, V., Pandey, P.C. and Jain, D.K. (2017). Anatomy of Angiosperms, RastogiPublication, Meerut.

Reference Books:

1. Eames, A.J. and Mc Daniels, L.H., (1953). An introduction to plant anatomy, Tata McGrow Hills, New Delhi
2. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
3. Tayal, M. S. (2012) Plant Anatomy Rajpal and Sons, New Delhi
4. Mishra, B. K. (2017). Anatomy of Angiosperms, Kalyani Publishers, New Delhi.
5. Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.

Core Paper VI
ECONOMIC BOTANY

Objectives:

1. To give a comprehensive idea about economic botany and its importance in human welfare.
2. To know the origin, introduction, domestication and evolution of new crops / varieties of crop plants.
3. To create awareness about importance of germplasm diversity.
4. To provide knowledge on general account, cultivation, propagation and uses of common crops.
5. To educate the students about the processing and uses of beverages, drug yielding plants and cash crops.

Outcomes:

After completion of the course the students shall

1. Have an understanding on the fundamental concepts of Economic Botany and its application in human welfare.
2. Be able to know the origin and evolution of crops and the importance of wild relatives in crop improvement
3. Develop a basic knowledge on germplasm and the basics for their conservation.
4. Be aware about the cultivation practices for important crops.
5. Have an understanding of plants as a source of food, beverages, spices, and materials.

Unit-I

(i) Origin of Cultivated Plants: Concept of Centers of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

(ii) Cereals: Cultivation and brief account of Wheat, Rice and millets.

(iii) Legumes: General account, importance to man and ecosystem.

(iv) Sugars & Starches: Morphology, cultivation and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, cultivation, propagation & uses.

Unit-II

(i) Spices: Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper Beverages: Tea, Coffee (morphology, processing & uses)

(ii) Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis.

(iii) Tobacco: Tobacco (Morphology, processing, uses and health hazards)

Unit-III

(i) Oils & Fats: General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* (Botanical name, family & uses)

(ii) Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit-IV

(i) Natural Rubber: Para-rubber: tapping, processing and uses.

(ii) Timber plants: General account with special reference to teak and pine. Fibers: Classification based on the origin of fibers, Cotton and Jute (morphology, extraction and uses).

PRACTICAL

(i) Cereals: Rice (habit sketch, study of paddy and grain, starch grains).
(ii) Legumes: Soya bean/moong bean/black gram, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
(iii) Sugars & Starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, starch grains, micro-chemical tests).
(iv) Spice and Beverages: clove, black pepper, Tea (plant specimen, tea leaves), Coffee(plant specimen, beans).
(v) Oils & Fats: Groundnut, Mustard–plant specimen, seeds; tests for fats incrushed seeds.
(vi) Drug-yielding plants: Specimens of *Digitalis, Papaver* and *Cannabis.*
(vii) Woods: *Tectona, Pinus*/Sal: Specimen, Section of young stem.
(viii) Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint andfuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Text Books:

1. B. P. Pandey, (2017) Economic Botany. S. Chand Publication, New Delhi.

Reference Books:

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi,India.
2. Samba Murty, A.V.S.S. and Subrahmanyam, N.S. (2011). Text Book of ModernEconomic Botany, CBS Publishers and Distributors, New Delhi.
3. Hill, Albert F. Economic Botany, Tata Mc Grow Hill Publishing Company, Ltd. NewDelhi.
4. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer AcademicPublishers, The Netherlands.
5. Singh, V., Pandey, P.C. and Jain, D.K. (2017). Economic Botany, RastogiPublication, Meerut.
6. Baruah, B. (2017). Economic Botany, Kalyani Publishers, New Delhi.

Core Paper VII
GENETICS

Objectives:

1. To know general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
2. Practical methodology for applying Mendelian laws (heavily reliant on problem solving).
3. Extensions of Mendelian genetics, including different forms of allelic relationships.
4. To know different types of mutations, affect genes and the corresponding mRNAs and proteins.
5. Inheritance of linked genes, including recombination mapping, and the physical basis of these rules (chromosomal behaviour during meiosis)

Outcomes:

On completion of the course the students shall

1. Learn the basic principles of inheritance at the molecular, cellular and organismal levels.
2. Understand the mechanism of inheritance and its relationship with the expression of morphological traits.
3. understand the relationships between molecule/cell level phenomena ("modern" genetics) and organism-level patterns of heredity ("classical" genetics)
4. Know about the variations by polyploidy, chromosomal aberration and gene mutations.
5. test and deepen their mastery of genetics by applying this knowledge in a variety of problem-solving situations.

Unit-I

(i) Mendelian genetics and its extension Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Interaction of genes, Pleiotropy, Recessive and Dominant traits, Polygenic inheritance.

(ii) Extrachromosomal Inheritance: Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; cytoplasmic male sterility; Maternal effects- shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Unit-II

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; Numerical based on gene mapping; Sex Linkage.

Unit-III

(i) Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

(ii) 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.

Unit-IV

(i) Fine structure of gene: Classical vs. molecular concepts of gene; Cis-Transcomplementation test for functional allelism; Structure of Phage T4, rII Locus.

(ii) Population and Evolutionary Genetics: Gene pool, Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift.Genetic variation and Speciation.

PRACTICAL

1. Analysis of allelic and genotypic frequencies.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-squareanalysis.
3. Chromosome mapping using test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3,15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Chromosome anomaly: Translocation Ring, Laggards and Inversion Bridge, break etc. (through photographs).

Text Books:

1. Singh B. D. (2017). Fundamental of Genetics, Kalyani Publishers, New Delhi.
2. Gupta P. K. (2017). Genetics, Rastogi Publication, Meerut.

Reference Books:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, JohnWiley & Sons, India. 8th edition.
2. Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. (1985) Principles of Genetics, TataMc Grow Hill, New Delhi
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. BenjaminCummings, U.S.A. 10th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction toGenetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.
5. Strickberger, M.W. Genetics, Pearson Publishers, 3rd Edition
6. Rastogi V. B. (2017). Genetics, Kedar Nath & Ram Nath, Meerut

Core Paper VIII
MOLECULAR BIOLOGY

Objectives:

1. To understand the Historical perspective of DNA and DNA as the carrier of genetic information.
2. To learn the Organization and structure of DNA and RNA in pro-and eu-karyotes.
3. To understand the structure and function organellar and nuclear genomes.
4. To understand the General principles of replication and the relationship with genetic code.
5. To study about Processing and modification of RNA in prokaryotes and eukaryotes for translation.

Outcomes:

On completion of the course the students shall

1. Be able to describe Organization and structure and replication of DNA and RNA.
2. Have theoretical and practical knowledge the prokaryotic and eukaryotic nucleic acids.
3. Have a clear understanding on the structure and function of organellar genome.
4. Understand the processes of bidirectional, semi-conservative and semi discontinuous mode of replication and the importance of the genetic code.
5. Have ability to understand the mechanism of translation in prokaryotes and eukaryotes.

Unit- I

Nucleic acids: Carriers of genetic information: Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty), Types of genetic material, denaturation and renaturation, cot curves. Organization of DNA and structure of RNA- Prokaryotes, Viruses, Eukaryotes, Fraenkel-Conrat's experiment. Organelle DNA - mitochondria and chloroplast DNA. The Nucleosome -Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit-II

(i) 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.

(ii) Central dogma and genetic code: Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

(iii) 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.

Unit-III

Mechanism of Transcription: Transcription in prokaryotes and eukaryotes;

Regulation of transcription in prokaryotes and eukaryotes: Principles of transcriptional regulation; Prokaryotes: Operon concept- Regulation of lactose metabolism and tryptophan synthesis in *E. coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing

Unit-IV

Translation (Prokaryotes and eukaryotes): Ribosome structure and assembly; 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.

PRACTICAL

1. Preparation of LB medium and raising E. coli.
2. Isolation of genomic DNA from suitable plant material.
3. RNA estimation by orcinol method.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Photographsestablishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of Barr body from buccal smear preparation.

Text Books:

1. Gupta P. K. (2017). Molecular Biology, Rastogi Publication, Meerut.

Reference Books:

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. Sheeler, P. and Bianchi, D.E. (2009) Molecular Biology of the Cell, Willey Publisher, New Delhi
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.
6. Alberts, B. et al. 2014. Molecular Biology of the cell Garland Science. 6th Edition
7. Power, C. B. (2017) Cell Biology, Himalaya Publishing House, New Delhi
8. Sahu, A.C. (2017). Essentials of Molecular Biology, Kalynai Publishers, NewDelhi.

Core Paper IX
PLANT ECOLOGY & PHYTOGEOGRAPHY

Objectives:

1. To learn the interaction of biotic components with non-living components of an ecosystem.
2. To introduce to various natural ecosystems and how the interaction among different biotic and abiotic factors influencing the stability and diversity of an ecosystem.
3. To study the physical, biological and chemical characteristics of factors influencing population.
4. To know the experimental approach to determine the physical, chemical and organic matters of soil.
5. To introduce the students to the characteristics and dynamism of population ecology.

Outcomes:

On completion of the course the students shall

1. Have ability to understand the ecological functioning of ecosystems and would certainly help students to maintain the local ecosystems.
2. Have information on species' geographical range and how the size and life history influenced by the various components of ecosystems.
3. An understanding of the factors that influence patterns of abundance and distribution in populations.
4. Have knowledge on the process of soil formation and approaches to study the nature of soils.
5. Have skill to evaluate the dynamics of change of population characteristics.

Unit-I

(i) Introduction Concept of ecology, Autoecology, Synecology, system ecology, Levelsof organization. Inter-relationships between the living world and the environment, the components of environment, concept of hydrosphere and lithosphere and dynamism, homeostasis.

(ii) Light, temperature, wind and fire: Variations; adaptations of plants to their variation.

Unit-II

(i) Soil: Formation; Composition; Physical; Chemical and Biological components; Soilprofile; Role of climate in soil development.

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

Unit-III

Biotic interactions and Population ecology: Characteristics and Dynamics.

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

Unit-IV

(i) Ecosystems: Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids.

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

(iii) Phytogeography: Principles; Continental drift; Theory of tolerance;Endemism; Phytogeographical division of India; Vegetation of Odisha.

PRACTICAL

1. Determination of pH of various soil and water samples (pH meter, universalindicator/Lovibond comparator and pH paper)
2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes, xerophytes, halophiles (two each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation inthe college campus, by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation for frequency, density and abundancein the college campus.
7. Field visit to familiarize students with ecology of different sites.

Text Books:

1. Sharma, P.D. (2017). Fundamentals of Ecology. Rastogi Publications, Meerut, India.

Reference Books:

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., NewDelhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and ResourceConservation. Anamaya Publications, New Delhi, India.
3. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth SystemsApproach. Oxford University Press. U.S.A.
4. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India.4th edition.
5. Santra, S. C. (2015) Environmental Science. New Central Book Agency (P) Ltd.Kolkata.
6. Das M. C. and Das S. P. (2009). Fundamental of Ecology. Tata MGrow Hill, NewDelhi.
7. Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.

Core Paper X
PLANT SYSTEMATICS

Objectives:

1. A comprehensive presentation of the rules, regulations and codes of governing principles of the International Code of Nomenclature of Algae, Fungi and Plants (ICN)
2. To provide knowledge on basic concepts of plant nomenclature and the tools used for naming the taxa.
3. To impart knowledge on the traditional and advanced systems of classification of lower and higher plants.
4. To acquaint the students with the modern approaches for developing systematic relationships in the plant kingdom.
5. To enlighten the students about the phylogeny and the methods for building phylogeny among taxa of various angiosperms.
6. To educate the students on the specific taxonomic characteristics of some angiosperm families and the method to make morphological studies of plant materials.

Outcomes:

After the completion of the course the students are expected to have

1. Knowledge on various levels of taxonomic hierarchy and the relationships among various hierarchical levels with respect to their similarities and variations of characters.
2. The skill to use various taxonomic literature, Flora and herbaria, keys of both physical and digital types for plant identification and floristic studies.
3. Critical thinking on the ancient, traditional and modern classification systems and evaluation of their applicability in taxonomic placement of taxa.
4. Knowledge on the evolution of the concepts in classifying plants and weighing the potential of various tools.
5. Ability to build the phylogeny among various taxa of different levels of hierarchy and identifying the apomorphy and plesiomorphy.
6. Critical observations of the morphology of plant materials for taxonomic description and identification to the family, genus and species level.

Unit I

Plant identification, Classification, Nomenclature; Biosystematics. 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

Unit-II

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

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.

Unit-III

(i) Systematics- an interdisciplinary science: Evidence from palynology, cytology, phytochemistry and molecular data.

(ii) Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus,

Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (up to series) and Hutchinson (up to series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit-IV

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).

Families of Angiosperms: Descriptive studies of Magnoliaceae, Rosaceae, Rubiacae, Poaceae, Orchidaceae, Musaceae, Acanthaceae, Apocynaceae, Asclepiadaceae, Lamiaceae.

PRACTICAL

(i) Study of vegetative and floral characters of available materials of the families included in theory syllabus (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification).

(ii) Field visit, plant collection and herbarium preparation and submission. Mounting of properly dried and pressed specimen of at least fifteen wild plants with herbarium label (to be submitted in the record book)

Text Books:

1. Sharma O. P. (2009) Plant Taxonomy, Tata Mc Grow Hill, New Delhi

Reference Books:

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-APhylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Saxena, H. O. and Brahman, M. The Flora of Orissa, CSIR Publication.
5. Bose T. K. (2009). Trees of the World, Regional Plant Resource Centre,Bhubaneswar, Odisha, India
6. Radford, A.E. (1986). Fundamentals of *Plant Systematics*. Harper and Row, NewYork.
7. Hanes, H. H. (2009). Botany of Bihar and Orissa,
8. Mohanty, C. R. (2017). Text Book of Plant Systematics, Kalynai Publisher, NewDelhi.
9. Subrahmainayam, M. S. (2011) Modern Plant Taxonomy, Vikash Publishing House,New Delhi
10. Pandey, B. P., (2017). Taxonomy of Angiosperm. S. Chand Publication.

Core Paper XI
REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Objectives:

1. To give a comprehensive idea about economic botany and its importance in human welfare.
2. To know the origin, introduction, domestication and evolution of new crops / varieties of crop plants.
3. To create awareness about importance of germplasm diversity.
4. To provide knowledge on general account, cultivation, propagation and uses of common crops and processing of the materials.
5. To know the extraction and uses of different oils as well as essential oils.

Outcomes:

After completion of the course the students shall

1. Have an understanding on the fundamental concepts of Economic Botany.
2. Develop a basic knowledge on the evolution of crops/varieties.
3. be aware about the importance of germplasm diversity and learn the methods for their conservation.
4. Increase appreciation of diversity of plants and plant products used in everyday life of human and the methods for their enhanced production.
5. Have an understanding of plants as a source of food, beverages, spices, and materials.

Unit-I

(i) Introduction: History and scope.

(ii) Anther: Anther wall: Structure and functions, micro-sporogenesis, callose deposition and its significance.

(iii) Pollen biology: Micro-gametogenesis; 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.

Unit-II

Ovule: Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– mega-sporogenesis and mega-gametogenesis; Types and ultrastructure of different mature embryo sacs (Details of *Polygonum* type), Developmental pattern of mono-, bi- and tetrasporic embryo sacs.

Unit-III

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

(ii) Self-incompatibility: Basic concepts; Methods to overcome self- incompatibility:mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface.

Unit-IV

(i) Endosperm: development, structure and functions

(ii) Embryo: Types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo- endosperm relationship; Nutrition of embryo; Embryo development in *Paeonia*.

(iii) Seed: Structure, importance and dispersal mechanisms

(iv) Polyembryony and apomixes: Introduction; Classification; Causes and applications.

PRACTICAL

(i) Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages throughslides/micrographs, male germ unit (MGU) through photographs and schematic representation.

(ii) 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.

(iii) Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Specialstructures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs). Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.

(iv) Embryogenesis: Study of development of dicot embryo through permanent slides/photographs; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

(v) Tracing the path of pollen tube.

(vi) Study of haustorial endosperm.

Text Books:

1. Singh, V., Pandey, P.C, and Jain, D.K. (2017). Reproductive Biology of Angiosperms,Rastogi Publications, Meerut

Reference Books:

1. Maheswari, P. (2009). Embryology of Angiosperms.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBHPublishing 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.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, VikasPublishing House. Delhi. 5th edition.
6. Mishra, B. K. (2017). Reproductive Biology of Angiosperms, Kalyani Publishers,New Delhi.

Core Paper XII
PLANT PHYSIOLOGY

Objectives:

This paper aims to educates students

1. about the mechanism and physio-chemical activities.
2. on nutrient uptake and translocation to different plant parts,
3. On the nature and physiological roles of various plant hormones on plant growth and development.
4. On the physiological requirements on plant morphogenesis and flowering
5. On the role of light responsive pigments in plant morphogenesis.

Outcomes:

On completion of the course the students will be able to understand and learn

1. the governing principles behind the various physiological life processes in plants.
2. about various uptake and transport mechanisms (water and solutes) in plants and the factors governing these processes.
3. the role of various plant hormones, signaling compounds, and stress responses.
4. The skills to manipulate the plant hormones in plants for desired morphological and physiological responses.
5. The climatic and physiological requirements for molecular signaling of plants for growth, differentiation, maturity.

Unit - I

Plant water relationship: Water Potential and its components, plasmolysis and imbibition, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, trans-membrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, anti- transpirants, mechanism of stomatal movement. 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.

Unit-II

(i) 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.

(ii) 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, and antiport.

Unit-III

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

Unit-IV

(i) Physiology of flowering: Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Senescence: Types and causes.

(ii) Phytochrome: Discovery, chemical nature, role of phytochrome in photo- morphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

PRACTICAL

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excisedtwig/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 throughstomata 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
8. To demonstrate suction due to transpiration.
9. Measurement of relation between transpiration and transpiring surface.
10. Measurement of cuticular resistance to transpiration.

Text Books:

1. Sinha, R. K. (2015). Modern Plant Physiology, Narosa Publishing House, New Delhi.

Reference Books:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wileyand Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology andDevelopment. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual.Narosa Publishing House, New Delhi.
4. Salisbury, F. B. and Ross, C. W. Plant Physiology Wadsworth PublishingCompany, California
5. Sahoo, A. C. (2018). Outlines of Plant Physiology Kalyani Publishers, New Delhi.
6. Srivastava, N. K. (2017). Plant Physiology, Rastogi Publications, Meerut.
7. Pandey and Sinha (2011). Plant Physiology, Vikash Publishing House, New Delhi

Core Paper XIII
PLANT METABOLISM

Objectives:

1. to learn the anabolic and catabolic cellular processes and their regulations.
2. to understand the mechanism of signal transduction in plants and the major signaling pathways.
3. to learn the photochemical and biochemical mechanisms for photosynthetic carbon fixation.
4. to learn the mechanism of carbon oxidation and ATP synthesis.
5. to understand the pathways of synthesis and oxidation and of lipids and fatty acids.
6. To understand the physiological and biochemical mechanism of nitrogen assimilation.

Outcomes:

On completion of the course the students shall

1. Be able to understand the importance of biochemical pathways and their regulatory mechanisms.
2. Have understanding of the signaling pathways and signal reception and delivery mechanisms.
3. Have an understanding of various carbon fixation pathways and their evolutionary significance.
4. Have proper level of knowledge on carbon oxidation and energy synthesis.
5. Know the processes of lipid metabolism and its importance in the germinating seeds.
6. Be able to understand the nitrogen assimilation pathways.

Unit - I

(i) Concept of metabolism: Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

(ii) Mechanisms of signal transduction: Calcium, phospholipids, cGMP, NO.

Unit-II

Carbon assimilation: Historical background, photosynthetic pigments, role of photosynthetic pigments, Red drop and Emerson Enhancement Effect, antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, C_3, C_4 pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction. Photorespiration.

Unit-III

(i) 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.

(ii) ATP-Synthesis: Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photo- phosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.

Unit-IV

(i) Lipid metabolism: Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluco-neogenesis and its role in mobilization of lipids during seed germination, α oxidation.

(ii) Nitrogen metabolism: Nitrate assimilation, free living and symbiotic biological nitrogen fixation (examples of legumes and non-legumes); Nitrification, Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and trans-amination.

PRACTICAL

1. Isolation and quantification 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. Demonstration of absorption spectrum of photosynthetic pigments.
7. Assay of the enzyme Catalase.
8. Photoreduction of dye by isolated chloroplasts.

Text Books:

1. Gupta, S, K. (2017). Plant Metabolism, Rastogi Publication, Meerut.

Reference Books:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wileyand Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology andDevelopment. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.
4. Sahoo, A. C. (2018). Outlines of Plant Metabolism, Kalyani Publishers, NewDelhi.

Core Paper XIV
PLANT BIOTECHNOLOGY

Objectives:

1. To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
2. To study about Somatic embryogenesis; Embryo culture and embryo rescue
3. To have theoretical and practical knowledge on Protoplast isolation, fusion, culture and Selection of hybrid cells for regeneration of hybrid plants.
4. To study about Recombinant DNA technology and its application.
5. To study various techniques of gene transfer and its application in plant improvement.

Outcomes:

On completion of the course the students shall

1. Have knowledge the about methods of Plant Tissue culture and its application.
2. Be able to describe the Somatic embryogenesis; Embryo culture and embryo rescue
3. Have skill to isolate plant Protoplast and differentiate the normal and hybrid protoplasts
4. Have knowledge the Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries
5. Gain knowledge on methods for developing transgenic plants and application of transgenics for human welfare.

Unit -I

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

Unit-II

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).

Unit-III

Recombinant DNA technology-II: Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, 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).

Unit-IV

Applications of Biotechnology: Pest resistant (Bt-cotton); herbicide resistant plants (Round Up 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 (Protease, Lipase); Genetically Engineered Products-Human Growth Hormone; Humulin; Biosafety concerns.

PRACTICAL

1. (a) Preparation of tissue culture (MS) medium.
   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf andnodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of another culture through photographs.
3. Preparation of artificial seeds.
4. Study of Bt cotton through photographs.
5. Isolation of plasmid DNA.
6. Gel electrophoresis (demonstration).

Text Books:

1. Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBHPublishing Co. Pvt. Ltd., New Delhi.

Reference Books:

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory andPractice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles andApplications of recombinant DNA. ASM Press, Washington.
3. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniquesand Applications. John Wiley & Sons Inc. U.S.A.
4. Singh, B. D. (2018). Plant Biotechnology Kalynai Publishers, New Delhi.
5. Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.
6. Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi

Discipline Specific Elective Paper-I

ANALYTICAL TECNIQUES IN PLANT SCIENCES

Objectives:

1. To learn the principles and operations of microscopes of various complexity and their application in biological studies.
2. To learn the techniques of centrifugation for separation of biological samples.
3. To learn the methods of radioisotopes measurement in and their importance in study of biological materials and processes.
4. To understand and the principles and applications of spectrophotometry and to understand the basic structural design of a standard instrument.
5. To learn about various chromatographic techniques in separation of plant extracts.
6. To acquaint the students with the advanced methods for characterization of biomolecules
7. To learn the procedures in processing the data and methods for data comparison.

Outcomes:

After the completion of the course the students are expected to have

1. Proper understanding of the microscopy and knowledge to analyze plant samples using electron microscopy and flow Cytometer.
2. Separation of biomolecules and cell organelle and appropriate application of the knowledge of centrifugation for the same.
3. Basic knowledge on the use of radioisotopes for analysis of biological samples.
4. Extraction and qualitative and quantitative analysis of extracts as well as the assay mixtutes using spectrophotometer.
5. skillful application of chromatographic techniques for separation of amino acids, pigments and biomolecules.
6. Proper method for characterizing protein and nucleic acids and skill on handling electrophoresis equipment for preparation of gels.
7. Methods for compilation, presentation, and analysis of biological data and selection of appropriate statistical method for comparison of data.

Unit-I

Imaging and related techniques: Principles of microscopy; Light microscopy; Fluorescence microscopy; Flow cytometry (FACS); Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting,freeze fracture, freeze etching.

Unit-II

Cell fractionation: Centrifugation: Differential and density gradient centrifugation,
Sucrose density gradient, $CsCl_2$gradient, analytical centrifugation, ultracentrifugation.Radioisotopes: Use in biological research, auto-radiography, pulse chase experiment.
Spectrophotometry: Principle and its application in biological research.

Unit-III

Chromatography: Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography. 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

Unit-IV

Biostatistics: Statistics, data, population, samples, variables, parameters; Representation of Data: Tabular, Graphical; Measures of frequency and central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variance, standard deviation; Chi-square test for goodness of fit. Test of significance: comparison of large, small and pairedsamples (T-Test) and correlation.

PRACTICAL

1. Study of different microscopic techniques for chromosome study
2. Study of PCR Demonstration.
3. To separate pigments by paper chromatography.
4. To separate phytochemicals by thin layer chromatography.
5. To estimate protein through Lowry's methods.
6. To separate proteins using PAGE.
7. To separate DNA (marker) using AGE.
8. Spectrometric estimation of total sugar by Anthrone method.
9. Chi-square analysis of mendelian ratio.
10. T-Test.

Text Books:

1. Patil, C. S. (2017). Advanced Analytical Techniques, ABE Books, New Delhi.

Reference Books:

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 Micro technique and Microscopy, Oxford UniversityPress, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rdedition.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.
5. Aneja, K. R. (2014). Laboratory manual of microbiology and biotechnology,Medtech, New Delhi

Discipline Specific Elective Paper-II
NATURAL RESOURCE MANAGEMENT

Objectives:

1. To introduce the types of natural resources and the concept of sustainable development.
2. To understand the status of biological diversity and their management.
3. To know the contemporary tools such as EIA and GIS for assessment and conservation of natural resources.
4. To know about the non-conventional energy resources and their application.
5. To learn the concept of resource accounting for better natural resource management.

Outcomes:

After the completion of the course the students shall

1. Be able to understand importance of each component of natural resources and try to use the available resources judiciously.
2. Know about different biological conventions and treaties emphasizing the conservation of biological diversities.
3. Clearly understand the importance of sustainable use of natural resources and procedures for their assessment.
4. Have skill to use renewable energy sources for the betterment of the human civilization and actively participate in popularization of the methods of energy and resource conservation.
5. Know the national and international efforts for management and accounting of natural resources.

Unit-I

(i) Natural resources: Definition and types.
(ii) Sustainable utilization: Concept, approaches (economic, ecological and socio-cultural).
(iii) Land: Utilization (agricultural, horticultural, silvicultural); Soil degradation andmanagement.
(iv) Water: Fresh water (rivers, lakes, groundwater, water harvesting technology, rainwater storage and utilization.

Unit-II

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

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

Unit-III

(i) Energy: Renewable and non-renewable sources of energy-solar, wind, tidal, geothermal and bioenergy resources.
(ii) Contemporary practices in resource management: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint.

Unit-IV

Resource Accounting; Waste management. National and international efforts in resourcemanagement and conservation

PRACTICAL

i. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
ii. Collections of data on forest cover of specific area.
iii. Measurement of dominance of woody species by DBH (diameter at breast height)method.
iv. Calculation and analysis of ecological footprint.
v. Ecological modeling.
vi. Estimation of soil moisture content and soil texture.
vii. Estimation of soil porosity
viii. Estimation of soil water-holding capacity.
ix. Estimation of soil organic matter and soil carbon

Text Books:

1. Pandey, B. W. 2005. Natural Resource Management. Mittal Publication, New Delhi

Reference Books:

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

Discipline Specific Elective Paper-III

HORTICULTURAL PRACTICES AND POST-HARVEST TECHNOLOGY

Objectives:

1. To introduce the concept, scope and importance of Horticulture for ecology, economic and aesthetics.
2. To understand the techniques for identification and requirements of horticulture crops.
3. To learn the methods of on field and post-harvest pest control in horticultural crops.
4. To learn the micro-propagation and conservation of important horticultural crops and the approaches thereof.
5. To understand the issues of IPR and various non-governmental initiatives in horticultural crop management.

Outcomes:

After the completion of the course the students are expected to have

1. An understanding on the importance of crop diversification and the contribution of horticulture to nutritional security and economic growth of the country.
2. Ability to classify ornamental, vegetable, fruit and floricultural import plants and their agroclimatic requirements.
3. Skill to identify the pests, pathogens and method of their control in horticultural crop by environment friendly approaches.
4. Skills on various modern methods of plant propagation and improvement of horticultural crops.
5. Knowledge to understand the IPR issues and the government and non-governmental initiatives at various complexities for conservation, popularization and improvement of horticulture.

Unit-I

(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.

(ii) 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)]

Unit-II

(i) Fruit and vegetable crops: Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops.

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

(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.

Unit-III

(i) 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;

(ii) 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;

Unit-IV

Horticultural crops - conservation and management: Documentation and conservation ofgermplasm; 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.

PRACTICAL

i. Identification and description of salient features of ornamental plants included inthe syllabus.
ii. Horticultural techniques (Drip irrigation, surface irrigation, furrow and borderirrigation).
iii. Study of practice of asexual propagation methods (grafting, cutting, layering,budding)
iv. Planning and layout of parks and avenues
v. Handing of harvested fruits, vegetables and cut flowers
vi. Methods of fruit preservation
vii. Basic tissue cultures technique

Text Books:

1. Peter, K. V. (2009). Basics of Horticulture, Kalyani Publishers, New Delhi.

Reference Books:

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

Discipline Specific Elective Paper-IV
INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

Objectives:

1. To introduce the practical knowledge on isolation of microorganisms from soil, air and water and their application.
2. To impart knowledge on the relationship between environmental quality and the microorganisms.
3. To learn to the basic concept on designing of bioreactors for microbial culture and their role in bioprocesses for value added products.
4. To understand the mechanism of microbial enzymes immobilization techniques used in bioprocesses engineering.

Outcomes:

On completion of the course the students shall be

1. Have skill to isolate, identify and culture the microbes isolated from various sources.
2. Have ability to draws idea of using the potential application of microbes for environmental quality assessment and remediation.
3. able to think and draw ideas in designing the bioreactor of their interest for industrial application.
4. Have knowledge on various biochemical application of microbes for production of value added products.

Unit-I

(i) Scope of microbes in industry and environment: Bioreactors/Fermenters andfermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors- laboratory.

(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.

Unit-II

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).

Unit-III

Microbes and quality of environment: Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

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.

Unit-IV

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.

PRACTICAL

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

3. Screening microorganisms for industrial use.
4. Mycorrhiza, arbuscular mycorrhizal colonization in plant roots.
5. Determination of BOD, COD, TDS and TOC of water samples.
6. Microorganisms as indicators of water quality

Text Books:

1. P. D. Sharma. (2017) Environmental Microbiology. Rastogi Publications, Meerut.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: Anapplication based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. PearsonBenjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Pradipta K. Mohapatra (2008). Text Book of Environmental Microbiology, I.K. International Publishing House, New Delhi
4. A. K. Rath (2018). Industrial and Environmental Microbiology, KalyaniPublishers, New Delhi.

OR

Discipline Specific Elective Paper-IV DISSERTATION / PROJECT WORK

Identification of problem	Review of Literature	Methodology	Findings	Analysis	Viva-Voce	Total
10	10	10	25	25	20	100

** = Students who score more than ≥60% in aggregate are eligible for project work

Generic Elective Paper I A
BIODIVERSITY (MICROBES, ALGAE, FUNGI AND ARCHEGONIATES)

Objectives:

1. To learn about the diversity, pathogenicity and importance of viruses.
2. To know about the characteristics and importance of bacteria.
3. To have a general understanding on the morphological diversity and ecological distribution of algae and fungi.
4. To learn about the general features of bryophytes and pteridophytes.
5. To learn about the characteristics of gymnosperms and the ecological distribution of gymnosperm vegetation.

Outcomes:

On completion of the course the students shall

1. Have knowledge on viruses and the viral replication cycles.
2. Be able to understand the physiology of and application of bacteria for human welfare.
3. Knowledge on various types of algae and fungi as well as their distribution in nature.
4. Be able to understand the characteristics and uniqueness of lower plants (bryophytes and pteridophytes).
5. Knowledge on the gymnosperm flora and their importance to the nature.

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.

Unit-II

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

(ii) 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* (Ascomycota), *Puccnia, Agaricus* Basidiomycota); Symbiotic Associations-Lichens.

Unit-III

(i) **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).

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

Unit-IV

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

PRACTICAL

1. Gram staining
2. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus* and *Polysiphonia* through temporary preparations and permanent slides.
3. *Rhizopus and Penicillium*: Asexual stage from temporary ounts and sexual structures through permanent slides.
4. *Puccinia* and *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
5. *Marchantia and Funaria*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
6. *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).
7. *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).
8. *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).
9. *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).

Text Books:

1. Mitra, J.N., Mitra, D. and Choudhury, S.K. Studies in Botany Volume 1. MoulikPublisher, Kolkata. Ninth Revised Edition

Reference Books:

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, PearsonBenjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, Mac MillanPublishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, JohnWiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGrawHill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) LtdPublishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central BookDepot, Allahabad.
9. Pandey, B. P. (2017), Botany for degree studies (as per CBCS). S. Chand
10. Acharya, B. S. and Mishra, B. K. (2018). Plant Biodiversity, Kalyani Publishers,New Delhi.

Generic Elective Paper IIA
PLANT PHYSIOLOGY AND METABOLISM

Objectives:

1. To learn the physiological processes of plants and the environmental factors regulating such processes.
2. To know about the nutrient requirements of plants and mechanism of nutrient uptake and translocation.
3. To understand the carbon assimilation processes in plants.
4. To learn about characteristics and mechanism of enzyme catalysis.
5. To learn about the properties and physiological roles of plant hormones.

Outcomes:

On completion of the course the students shall

1. Have knowledge on the vital physiological processes of plants and their importance in plant growth and Survival.
2. Understand the nutrient uptake and translocation in plants under various environmental and nutrient regimes.
3. Have a clear understanding on the processes of and Photosynthesis and organic carbon oxidation.
4. Be able to know the metabolic pathways of cells and their regulation by enzymes.
5. Have an idea about the physiological roles of various plant hormones and knowledge on the application of hormones on Plant growth and development.

Unit-I

(i) Plant-water relations: Importance of water, water potential and its components;Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

(ii) 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.

(iii) Translocation in phloem.: Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading

Unit-II

(i) Photosynthesis: Photosynthetic Pigments (*Chl* a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C_3, C_4 and CAM pathways of carbon fixation.

(ii) Respiration: Glycolysis, anaerobic respiration, TCA cycle; Oxidative Phosphorylation.

Unit-III

(i) Enzymes: Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

(ii) Nitrogen metabolism: Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit-IV

(i) Plant growth regulators: Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

(ii) Plant response to light and temperature: Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far-red light responses on photomorphogenesis; Vernalization.

PRACTICAL

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

Text Books:

1. A. C. Sahu (2018). Plant Physiology and Metabolism. Kalyani Publishers, New Delhi.

Reference Books:

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology andDevelopment. 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.
4. H. S. Srivatava. Plant Physiology, Rastogi Publications, New Delhi

Generic Elective Paper I(B)
PLANT ECOLOGY AND TAXONOMY

Objectives:

1. To educate the students about the ecology and environment and the ecological factors regulating ecosystems.
2. To impart Knowledge on structure and the successional changes of plant communities.
3. To know the basics of plant nomenclature and the use of tools for plant identification.
4. To learn the basic principles of classification of angiosperm and their application and correct placement of a taxon in the taxonomic hierarchy.
5. To know the morphology and taxonomic description of different families of monocots and dicots.

Outcomes:

After the completion of the course the students are expected to have

1. The knowledge about various ecological factors and their influence on the ecosystems.
2. Practical knowledge and skill to analyze various ecosystem characteristics and estimation of phytosociology of a community.
3. Detailed information on the principles and rules of ICN for correct identification and nomenclature of plants.
4. Knowledge on various types of classifications of flowering plants and their use for compilation of flora, keys as well as taxonomic arrangement in herbaria.
5. Skill to taxonomically analyze various plant samples and to identify the plant samples to species level.

Unit I

(i) 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

(ii) Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types

Unit-II

(i) Ecosystem: Structure; Biotic and abiotic components, energy flow trophic organization; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

(ii) Phytogeography: Principal biogeographical zones, Endemism.

Unit-III

(i) Introduction to plant taxonomy: Identification, Classification, Nomenclature.

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

Unit-IV

(i) Taxonomic hierarchy: Ranks, categories and taxonomic groups

(ii) 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.

(iii) Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Hutchinson (upto series).

(iv) Taxonomic description of the families: Malvaceae, Fabaceae, Asteraceae and Poaceae, Apocynaceae, Lamiaceae and Musaceae.

PRACTICAL

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, raingauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides,nitrates, sulphates, organic matter and base deficiency by rapid field test.
3. Comparison of bulk density, porosity and rate of infiltration of water in soil of threehabitats.
4. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each). (b)Study of biotic interactions of the following: Stem parasite (*Cuscuta)*, Root parasite
5. (*Orobanche*), Epiphytes, Predation (Insectivorous plants)
6. Determination of minimal quadrat size for the study of herbaceous vegetation in thecollege campus by species area curve method. (species to be listed)
7. Quantitative analysis of herbaceous vegetation in the college campus for frequencyand comparison with Raunkiaer's frequency distribution law .
8. Study of vegetative and floral characters of the families as in theory syllabus (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e andsystematic position according to Bentham & Hooker's system of classification).
9. Mounting of properly dried and pressed specimen of any ten wild plant's withherbarium label (to be submitted in the record book).

Text Books:

1. Sharma, P.D. (2017). Fundamentals of Ecology. Rastogi Publications, Meerut, India.

Reference Books:

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. 8thedition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA,U.S.A.
4. Singh, G. (2012). *Plant Systematics:* Theory and Practice. Oxford & IBH Pvt. Ltd., NewDelhi. 3rd edition.
5. Sahu, A. C. (2017). Plant Ecology and Phytogeography, Kalyani Publishers, New Delhi.
6. Das, M. C. and Das, S. P. (2009). Fundamental of Ecology. Tata MGrow Hill, NewDelhi.
7. Shukla, R.S. and Chandel, P.S. (2016). A text book of Plant Ecology. S ChandPublication, New Delhi
8. Mohanty, C. R. (2017). Text Book of Plant Systematics, Kalynai Publisher, New Delhi.

Generic Elective Paper II(B)
PLANT ANATOMY AND EMBRYOLOGY

Objectives:

1. To know the diversity of tissues and cells in plants.
2. To know the development of different tissues from the embryo.
3. To study the apical organization and differentiation of the dermal and internal tissues of shoot and root
4. To understand the process and requirements for pollination and fertilization.
5. To know the process of development of embryo and endosperms.

Outcomes:

On completion of the course the students shall

1. Be able differentiate tissues and conceptualize the integrated organismal structure and function.
2. Understand the differentiation of tissues from embryo during seed germination.
3. Have an understanding of the differentiation of vascular, cortical and dermal tissues from the apical meristems.
4. Have knowledge of pollination and how to overcome the incompatibility barrier.
5. A broad understanding of the embryo and endosperms and their interrelationships.

Unit-I

(i) Meristematic and permanent tissues : Root and shoot apical meristems; Simple and complex tissues

(ii) Organs: Anatomy of dicot and monocot root stem and leaf.

Unit-II

(i) Secondary Growth: Vascular cambium – structure and function, seasonal activity. Secondary growth in and stem, Wood (heartwood and sapwood)

(ii) Adaptive and protective systems: Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit-III

(i) 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.

(ii) Pollination and fertilization: Pollination mechanisms and adaptations; Doublefertilization;

Unit-IV

(i) Endosperm: Endosperm types, structure and functions.

(ii) Embryo: Dicot and monocot embryo; Structure and development, Embryoendosperm relationship.

(iii) Seed-structure and development, appendages and dispersal mechanisms.

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 Permanentslides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanentslides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanentslides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous**.**

Text Books:

1. Singh, Pandey and Jain (2017). Anatomy of Angiosperms, Rastogi Publication, Meerut.

Reference Books:

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. VikasPublication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
3. C. R. Mohanty (2018). Plant Anatomy and Embryology. Kalyani Publishers, NewDelhi.

OPTIONAL FOR SECC II PAPER

Skill Enhancement Course (SECC II Option I)

BIO-FERTILIZERS

Objectives:

1. To understand the methods of isolation, propagation, and application of different bacterial, fungal and algal biofertilizers.
2. To learn the characteristics of strains of importance for use as biofertilizers and the methods of their cultivation, processing and application.
3. To inculcate the knowledge for understanding the concept and procedure of organic farming for sustainable agroecosystem.
4. To learn the processing and recycling methods of biodegradable organic wastes of diverse origin and their integration with biofertilizers.
5. To learn the techniques and application of composting, vermin-composting and reuse of complex organic maters and method of their agricultural application.

Outcomes:

After the completion of the course the students are expected to have

1. Knowledge of biofertilizers belonging to different microbial groups and their association with crop plants.
2. Skill on isolation, culture, mass propagation and harvesting, processing, storage and marketing of various types of biofertilizers.
3. Detailed understanding on the techniques and benefits of organic farming following green manuring and organic manure application.
4. Knowledge on the nutritional advantage of the application of biofertilizers and the field doses of various biofertilizers for nitrogen and phosphorus nutrition.
5. Skill to properly compost the organic wastes of various complexity and use of the compost on crop field for enhanced yield.

Unit-I

General account about the microbes used as biofertilizer– Rhizobium – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis. *Azospirillum*: isolation and mass multiplication, *Azotobacter*: classification, characteristics – crop response to Azotobacter inoculums, maintenance and mass multiplication.

Unit-II

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

Unit-III

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.

Unit-IV

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal,

agricultural and Industrial wastes – bio compost making methods, types andmethod of vermicomposting – field Application.

Text Books:

1. Mahendra Rai, (2006). Hand book of Microbial Bio-fertilizers. CRC Press.

Reference Books:

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
7. Pravin Chandra Dwivedi. (2008). Biofertilizers. Pointer Publishers.

Skill Enhancement Course (SECC II Option II)
NURSERY AND GARDENING

Objectives:

1. To give a general concept on the nursery techniques and requirements.
2. To impart knowledge on seeds and seed technology.
3. To learn about the methods of propagation of plants in the nurseries and infrastructural requirements.
4. To give a general knowledge on the gardening techniques at different scales.
5. To impact knowledge on modern methods of gardening with respect to the application of computer technology.
6. To learn the techniques of raising seedlings of common horticulturally and agriculturally important plants.
7.

Outcomes:

On completion of the course the students shall

1. Have knowledge on plants and planting methods.
2. Be able to understand the process for storing seeds and plant propagules.
3. Skills on various methods of propagation and requirements of production of propagules.
4. Able to understand the type of gardens and methods to develop a garden.
5. Have knowledge on garden management and disease control.
6. Have ability to cultivate commonly used vegetable crops and understand the method of cultivation.

Unit- I

Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.

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.

Unit-II

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.

Unit-III

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.

Unit-IV

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.

Text Books:

1. Saidaiah Pidigam, Sindhuja S., Geetha Amarapalli. (2018) Text Book of Nursery,Gardening and Floriculture, Kalyani Publishers, New Delhi.

Reference Books:

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., NewDelhi.
5. Agrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture andCooperation, National - Seed Corporation Ltd., New Delhi.
6. Janick Jules. 1979. Horticultural Science. (3rd Ed.), W.H. Freeman and Co., SanFrancisco, USA.

Skill Enhancement Course (SECC II Option III)
ETHNOBOTANY

Objectives:

1. To educate the students about the concept and importance of ethnobotany as an interdisciplinary science.
2. To learn about the tribals / ethnic groups of India, their life style and their role in conservation of medicinal plants.
3. To acquire basic knowledge about key medicinal plants used in ethnobotany.
4. To understand the legal aspect of ethnobotany.

Outcome:

After the completion of the course the students are expected to

1. Conceptualize the importance of ethnobotany as an interdisciplinary science.
2. Understand various methodology of ethnobotany studies and traditional practices for conservation of knowledge and plants.
3. Have an understanding about the taxonomic and medicinal importance of widely used medicinal plants.
4. Understand the legal aspect associated with ethnobotany, biopiracy and Intellectual Property Rights to protect the interest in tribals.

Unit-I

(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.

(ii) Methodology of Ethnobotanical studies a) Field work b) Herbarium c) AncientLiterature d) Archaeological findings e) temples and sacred places.

Unit-II

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) *Azadiracta 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*.

Unit-III

Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forestmanagement (participatory forest management).

Unit-IV

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.

Text Books:

1. Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd

Reference Books:

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, Palaeo ethnobotany
4. S.K. Jain (ed.) 1989. Methods and approaches in Ethnobotany. Society ofEthnobotanists, 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 AndhraPradesh, India. Botanical Survey of India. Howrah.
8. Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996
9. Rath, A. K. and Mishra, S. R. (2017). Ethnobotany, Kalyani Publishers, New Delhi.

Skill Enhancement Course **(SECC II Option IV)**

MUSHROM CULTIVATION

Objectives:

1. To study about types, nutritional and medicinal value of edible mushrooms and the toxicity of Poisonous Mushrooms.
2. To learn the Cultivation Technology of edible mushrooms and its regulating factors.
3. To know about short-term and long-term storage of mushrooms and their products.
4. To understand the Cost benefit ratio - Marketing in India and abroad.

Outcomes:

On completion of the course the students shall

1. Have knowledge about the importance for integrating mushroom as an alternate nutritive food. Mushrooms.
2. Have knowledge and skills for Cultivation of edible mushrooms.
3. Know about the edible mushrooms available in India and their processing and storage methods.
4. Have an understanding about the Low-cost cultivation Technology of edible mushrooms and adoption of mushroom cultivation as a profitable entrepreneurship.

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*. 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.

Unit-II

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.

Unit-III

Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickles, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fiber content - Vitamins.

Unit-IV

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

Text Books:

1. B. C. Suman and V. P. Sharma. (2007). Mushroom Cultivation in India. DayaPublishing House, New Delhi.

Reference Books:

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.
5. Anon. (2010). The Cultivation of Mushrooms - An Outline of Mushroom Culture, Read Book Design, New Delhi

VALUE ADDED COURSES
(OPTIONAL)

PROTEIN SEPARATION TECHNIQUES (VA -I)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. to understand the complexity in separation methods in proteins from biological samples.
2. to understand different methods employed by researchers in protein separation, purification and characterization.
3. to understand regarding different instruments used in the process.

Outcomes:

On completion of the course the students shall have

1. an idea for performing experiments and separating proteins from biological samples.
2. ability to choose suitable experimental strategies when analyzing protein experiments.
3. an exposure to equipment used in protein research.

UNIT-I

Chromatography: Fundamental terms and Concepts, History of protein chromatography, Biophysical properties of peptides and proteins, Stationary vs mobile phase, Chromatographic procedure and Chromatography Techniques, Types of Chromatography - Size Exclusion Chromatography, Ion-Exchange Chromatography, Reversed Phase Chromatography, HPLC and Coupled instrumentation.

UNIT- II

Electrophoresis: Historical development, Principle and behaviour of proteins in electrophoresis, Equipment and Sample preparation, Disc-and SDS-PAGE electrophoresis. Iso-Electric focusing and 2D electrophoresis: working principle and instrumentation. DIGE; Electroblotting-Blot systems, blot membranes and transfer buffers.

UNIT-III

Mass Spectrometry: Historical development, Instrumentation, Types of Ionisation methods - MALDI-MS and ESI-MS. Types of Mass Analysers - TOF, Quadrapole, Orbital, Types of Ion detectors and fragmentation techniques. Determination of mass and identification, detection and structural elucidation. Fundamentals of LC-MS and LC-MS/MS.

Books:

1. Wilson, K., Hofmann, A., Walker, J. M., & Clokie, S. (Eds.). (2018). Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge University Press.
2. Janson, Jan-Christer, ed. Protein purification: principles, high resolution methods, and applications. Vol. 151. John Wiley & Sons, 2012.
3. Bisen, Prakash Singh, and Anjana Sharma. Introduction to instrumentation in life sciences. Crc Press, 2012.

MICROBES AND ENVIRONMENT (VA-II)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives :

1. To introduce the students to the types of solid waste and their management using different microbiological approaches.
2. To introduce the students to the fundamental concepts of pesticide degradation and roles of different enzymes in pesticide transformation.
3. To introduce certain microbial bioprocess techniques with immense application in industries for value added products.
4. To introduce the students to the concept of producing bioenergy by using microbial resources.

Outcomes:

1. The paper provides information on certain microbiological methods for the management of solid waste and detoxification of heavy metals.
2. Student would learn about different pathways for biodegradation of xenobiotic pollutants using microbes.
3. Student would learn about different microbial techniques used for the application of important microbes for industrial application.
4. Student would learn about roles of different microbes for the preparation of biogas and bioethanol as non-conventional energy sources.

UNIT-I Waste Management and Microbial remediation

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants. Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.

UNIT- II Microbes in Biotransformations

Microbial based transformation of steroids and sterols. Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute. Microbial product purification: filtration, ion exchange & affinity chromatography techniques Immobilization methods and their application: Whole cell immobilization.

UNIT- III Microbes for Bio-energy and Environment

Bio-ethanol and bio-diesel production: commercial production from lingo-cellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture.

SUGGESTED READING

1. Gupta PK (2009) Elements of Biotechnology 2nd Edition, Rastogi Publications.
2. Tortora GJ, Funke BR and Case CL (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
3. Madigan MT, Martinko JM, Dunlap PV and Clark DP (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.
4. Wiley JM, Sherwood LM and Woolverton CJ (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.

BIODIVERSITY AND CONSERVATION (VA-III)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives

1. To gain in depth knowledge on biodiversity of the planet earth.
2. To understand the status, value and causes of biodiversity loss.
3. To know the fundamentals and scientific principles of conservation.
4. To know the environmental importance of biodiversity.
5. To gain knowledge about practical issues with conservation and various projects involved.

Outcomes:

On completion of the course the students shall

1. Understand the international and national status of biodiversity and the associated concerns Know the importance of biodiversity and causes of diversity loss.
2. Have ability to make planning for protection and conservation of biodiversity.
3. Understand the ecological, social, and economic impacts of diversity loss,
4. Understand the management principles and tools that are used to conserve diversity.

UNIT-I

Biodiversity: Definition, Importance, Types and Levels of biodiversity. Measurement of biodiversity-species richness and abundances, diversity indices-Shannon's, Simpson's Biodiversity and various ecosystem services, Biodiversity as bio resources-use and values of biodiversity as sources of food, fodder, timber, medicinal and ornamental plants. National Biodiversity Authority, community biodiversity registers.

UNIT-II

Threats to and loss of biodiversity: Causes: habitat loss, invasive species, industrialization, population growth, pollution, climate change, overharvesting/ overexploitation (including poaching), Consequences of biodiversity loss. Conservation strategies: *In situ* and *ex situ* conservation, mega diversity countries, biodiversity hot spots, UNESCO Biosphere reserves, National parks and Wildlife sanctuaries, Botanical gardens, Seed bank Role of tissue culture in conservation.

UNIT-III

Overview of Conservation efforts: IUCN Protected areas and functions; IUCN conservation categories of threats, Red Data Books. UNEP-World Conservation Monitoring Centre (WCMC), CITES. Wild life conservation projects: Crocodile Conservation, Project Tiger, GOI-UNDP Sea Turtle project.

BOOKS:

1. Gaston, K.J (2004). Biodiversity: An Introduction, Atlantic Publishers Distributors, India 2nd edition.
2. Maiti, P.K and Maiti, P (2011). Biodiversity: Perception, Peril and Preservation, PHI Learning, India, 1st edition.
3. Primack, R.B (2014). Essentials of Conservation Biology, Sinauer Associates, Oxford University Press. USA, 6th edition.
4. Dubey K. (2011) Biodiversity Threats to Conservation, S.K. Publishing Company.

ADD ON COURSES (OPTIONAL)

STATISTICS IN BIOLOGY(AO-I)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To learn the appropriate statistical measurement for analysis of biological data.
2. To study the application of modern statistical methods for intra sample and inter sample comparison.
3. To learn the development of program sheet for calculation of t, F and Chi² values.
4. To learn the application of MS-Excel for statistical comparison.
5. To learn the trend analysis and prediction of the relationship among variables.

Outcomes:

On completion of the course the students shall

1. Understand the requirement of the measurement of dispersion in processing of biological data and for determining the data homogeneity.
2. Understand the scope and application of LSD, DMRT for inter sample comparison.
3. Shall be able to prepare program for t, F, Chi² and dispersion using computer.
4. Develop the skill for use of MS-Excel for statistical calculation and data interpretation.
5. Develop the knowledge to understand the relationship between variables.

UNIT-I

Measurement of dispersion of small and large samples, Intrasample variation, Least significant difference test; LSD values for comparison of means; Duncan's multiple range test (DMRT); standardized range for DMRT; Program sheet of LSD and DMRT using MS-Excel. Application of LSD and DMRT in analysis of dispersion in biological samples.

UNIT-II

Comparison between means; Paired and unpaired t-test; Analysis of variance-one factor and two factor analysis of variance (ANOVA), factorial design and estimation. Factorial analysis sheet using MS-Excel; Biological applications of t-test and ANOVA.

UNIT-III

Trend analysis and fitting predictions, dependent and independent variables; Regression analysis; Estimation of the slope and residual errors. Correlation coefficients, simple linear and nonlinear regression and correlation; quadratic equations for determining non-linear relationships; Two factor and three factor multiple correlations. Trend analysis using MS-Excel. Applications of fitting predictions in biological data analysis.

BOOKS:

1. Introductory Practical Biostatistics-B.N. Mishra and M.K. Mishra, Naya Prakash, Kolkatta
2. Biostatistical Analysis-J.H. Zav, Pearson Education, Singapore.
3. Statistical Procedure for Agricultural Research-K.A. Gomez and A.A. Gomez, Wiley Interscience

SECONDARY METABOLITES OF PLANTS (AO-II)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To know the pathways of secondary metabolites production.
2. To study the different tissue culture protocols for secondary metabolite production.
3. To compare the types of secondary metabolites using different techniques.

Outcomes:

On completion of the course the students shall

1. Understand the secondary biosynthetic pathways and have knowledge for manipulation of the rate of synthesis
2. Have knowledge on the in vitro methods of secondary metabolite production.
3. Have ability to identify the most efficient and cost effective method for secondary production.

UNIT-I

Plant derived chemicals: Primary metabolites and secondary metabolites, origin, types, structure and function; Morphological and chemical differentiation; secondary metabolites as a source of defense to biotic and abiotic stresses. Industrial applications

Unit-II

Methods for secondary metabolite production: Plant cell, tissue & organ culture; Shoot culture, Root culture Callus culture, Cell suspension culture, Somaclonal variations and Hairy root culture using *Agrobacterium rhizogenes*. Protocol for i*n vitro* axillary and adventitious shoot cultures, Protocol for in vitro callus and cell suspension cultures etc.

Methods to enhance the production of secondary metabolites: Metabolic engineering, Precursor feeding, Biotransformation and Mass multiplication using bioreactor.

Unit-III

Different methods for extraction of secondary metabolites: Multi-elemental analysis by EDXRF and EPIXE techniques, qualitative phytochemical and antimicrobial analysis, quantification by TLC, HPLC, HPTLC and identification by NMR. Institutes involved in this work (IMMT, IOP & NISER Bhubaneswar, CIMAP / CDRI, Lucknow etc.)

BOOKS:

1. Plant Biotechnology: K.G. Ramawat; S. Chand & Company Ltd., New Delhi-110 055
2. Plant Tissue Culture (Protocols in Plant Biotechnology): M.C. Gayatri and R. Kavyashree; Narosa Publishing House Pvt. Ltd., New Delhi-110 002
3. Plant Tissue Culture: S. Kumar, S. Mishra and A.P. Mishra; Scientific Publishers (India), Jodhpur-342001
4. Introduction to Genetic Engineering of Crop Plants (Aims & Achievements): A. Rashid; I.K. International publishing house Pvt. Ltd., New Delhi-110007

DEVELOPMENT OF TRANSGENIC PLANTS (AO-III)

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To study about gene and different vectors
2. To learn about the *Agrobacterium*-mediated Methods of gene transfer
3. To study about various other way of gene transfer
4. To know about Selection of transgenics and Confirmation of transgenic plant
5. To understand about Transgenic crops tolerating biotic and abiotic stress

Outcomes:

On completion of the course the students shall

1. Have knowledge about the different vectors to clone the genes
2. Have clear understanding of *Agrobacterium*-mediated Methods of gene transfer
3. Have ability to understand diverse methods of gene transfer and selection of appropriate method.
4. Gain knowledge about how to Select transgenics plant and confirm the presence of the trait of interest.
5. Be able to describe various types of Transgenic crops tolerating biotic and abiotic stress

UNIT-I

Cloning of gene plant expression vector and construction of gene Construct. Agrobacterium-mediated Methods of gene transfer and by other way of gene transfer by Electroporation, Microinjection, Microprojectile bombardment etc. Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP). Confirmation of transgenic plant by PCR and Southern Blotting etc.

UNIT-II

Transgenic crops with improved Biotic stress resistance (Insect/ Pest resistant: Bt-cotton; herbicide resistant plants: RoundUp Ready soybean; Fungus and virus resistance etc.), Abiotic stress tolerance (Salinity, Drought, Heat, submergence), Role of transgenics in bioremediation.

UNIT-III

Transgenic crops with improved nutritional traits (Golden rice, Tearless Onion, Flavr Savr tomato, Purple tomato with high anthocyanin pigment, mushroom with high protein), Edible Vaccine (Corn based edible Vaccine), Human Growth Hormone (Humulin), Biosafety regulations.

BOOKS:

1. Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Singh, B. D. (2018). Plant Biotechnology Kalynai Publishers, New Delhi.
3. Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.
4. Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi

CAPACITY BUILDING OF FACULTY

Following modules have been proposed for training of faculties:

- Isolation and quantification of nucleic acids following spectrophotometricand gel electrophoresis techniques
- Techniques of Chromatography
- Micrometry and Hemocytometry
- Tissue Culture Techniques
- PCR techniques
- Chromosome techniques

The above module may be of 3-4 weeks duration with 30 participants.

LIST OF EQUIPMENTS

Sl. No.	List of Equipment's	Quantity
01	Dissecting Microscope (Indian Make)	2 no.
02	Compound Microscope (Indian Make) with photographic attachment	2 no.
03	Ocular and Stage Micrometer (Indian Make)	1 no.
04	UV Spectrophotometer (Indian Make)	1 no.
05	Cold Centrifuge (Indian Make)	1 no.
06	Refrigerator (Indian Make)	1 no.
07	Soil Thermometer (Indian Make)	1 no.
08	Anemometer (Indian Make)	1 no.
09	Psychrometer (Indian Make)	1 no.
10	Rain gauge (Indian Make)	1 no.
11	pH meter (Indian Make)	1 no.
12	Herbarium Press (Indian Make)	1 set
13	Hot air Oven (Indian Make)	1 no.
14	Electronic Balance (Indian Make)	1no.
15	Gel Electrophoresis (Indian Make) Vertical and submarine	1 no.
16.	Power Pack for electrophoresis	1 no.
17	Blood Testing Kit (Indian Make)	1 no.
18	Laminar Flow (Indian Make)	1 no.
19	BOD Incubator (Indian Make)	1 no.
20	Autoclave (Indian Make)	1 no.