Ch. Charan Singh University,Meerut
M.Sc. Botany Syllabus Revised on 13.03.2018
Effective from session 2018-19(For II and IV sem from 2017-18)
Distribution of marks in different courses

I Semester	Course Title	Total Marks(Int.+Ext.)
Course I/ H1001	Angiosperm Taxonomy, Plant Resources and Utilization	50+50
Course II/ H1002	Biology and Diversity of Viruses and Bacteria	50+50
Course III/ H1003	Biology and Diversity of Algae and Bryophytes	50+50
Course IV/ H1004	Biology and Diversity of Pteridophytes, Gymnosperms and Palaeobotany	50+50
Practical -I (H501)(4 Hours)	Based on Courses I-IV	100
	Total marks	500

II Semester	Course Title	Total Marks
Course V/ H 2001	Fungal Biodiversity and Elementary Plant Pathology	50+50
Course VI/ H 2002	Cell and Molecular Biology	50+50
Course VII/ H2003	Genetics, Cytogenetics and Plant breeding	50+50
Course VIII/H2004	Anatomy and Reproduction in Angiosperms	50+50
Practical II (H 601) (4 Hours)	Based on Courses V-VIII	100
	Total marks	500

III Semester	Course Title	Total Marks
Course IX/ H3001	Plant-Soil-Water relations; Growth and Development	50+50
Course X/H3002	Phytochemistry and Metabolism	50+50
Course XI/H3003	Plant Ecology and Phytogeography	50+50
Course XII/H3004	Elementary Biotechnology	50+50
Practical III (H 701) (4 Hours)	Based on theory courses IX-XII	100
	Total marks	500

IV Semester	Course Title (Compulsory Courses)	Total Marks
Course XIII/H4001	Modern Phytotechniques and Biostatistics	50+50
Course XIV/H4002	Biodiversity conservation and Plant Resources	50+50
	Elective Courses (Any two courses)	
Course XV /H4003	Recombinant DNA technology	50+50
Course XVI /H4004	Plant Tissue Culture	50+50
Course XVII /H4005	Microbial Biotechnology	50+50
Course XVIII /H4006	Environmental Biotechnology	50+50
Course XIX /H4007	Stress Physiology of Plants	50+50
Course XX /H4008	Applied Plant Physiology	50+50
Course XXI /H4009	Diversity in Plants, their origin and evolution	50+50

Course XXII /H4010	Elementary Computer Knowledge and Bioinformatics	50+50
Course XXIII/H4011	Plant Pathology	50+50
Practical IV (H801)(4 Hours)	Based on theory courses XIII-XIV and two out of XV-XXIII	100
	Total marks	500
	Grand Total	2000

A candidate can select any two elective courses from XV to XXIII (as per availability in the institution) to serve as specialization. Each course will have 4 hours theory and 4 hours practical in each week.
A minimum of 30% marks separately in internal and external assessment of each course and an aggregate of 40% marks in all the courses is required for passing. In case of failing to obtain 30 % marks in internal assessment of any paper, the candidate will not be eligible to appear in external examination of that course.
Internal assessment will be based on :
Quizzes -2: (from first Unit) Each for 5 marks
Tests-2: for 15 marks each (based on 2 units each)
Seminar/ Term Paper: 10 marks in each paper

Course – I: Angiosperm Taxonomy, Plant Resources and Utilization 50 Hours

Unit- I 10 Hours

Taxonomy of Angiosperms:

1. History of plant Taxonomy.
2. International Code of Botanical Nomenclature (ICBN). Salient feature, important rules and recommendation, Binomial nomenclature, botanical gardens and herbaria.
3. Taxonomic evidences: Morphology, Plant anatomy, Palynology, Embryology, Cytology, Phytochemistry, Genome analysis and DNA hybridization technique in relation to taxonomy, numerical taxonomy, serotaxonomy.

Unit- II 10 Hours

4. The species concept: Taxonomic hierarchy, species, genus, family and other categories, Principles used in assessing relationship, delimitation of taxa and attribution of rank. Variation and specialization in plants.
5. Phylogenetic systems of classification: Hutchinson, Cronquist, Takhtajan and Dahlgren. Outlines, merits and demerits.
6. Basic knowledge of phylocode and A P G system.

Unit- III 10 Hours

7. Range of floral structure and phylogeny in:

I. **Dicotyledons:**

a. Magnoliidae with special reference to Magnoliaceae, Lauraceae, Piperaceae,
b. Hamamelidae with special reference to Moraceae, Juglandaceae and Casuarinaceae,
c.Caryophyllidae with special reference to Cactaceae, Chenopodiaceae and Polygonaceae,
d. Dilleniidae with special reference to Tiliaceae, Sterculiaceae, Violaceae,
e. Rosidae with special reference to Lythraceae, Combretaceae,
f. Asteridae with special reference to Boraginaceae, Scrophulariaceae, Bignoniaceae
,

Unit- IV 10 Hours

II.**Monocotyledons:**

a. Alismatidae,
b. Commelinidae with special reference to Commelinaceae and Zingiberaceae,
c. Arecidae with special reference to Araceae,
d. Liliidae with special reference to Amaryllidaceae

8. Cradle of flowering plants.

Unit- V 10 Hours

Plant resource utilization:

12. Botanical names, families, Plant part(s) used and uses of the important plants belonging to following categories:
    Fiber plants
    Spices and condiments
    Beverages
    Medicinal plants
    Non-wood plant products (NWPPs): rubber, dyes, resin, gums etc.

Course – II: **Biology and Diversity of Viruses and Bacteria** **50 Hours**

Unit – I **10 Hours**

1. Development of microbiology as science, important contribution of pioneer microbiologists; golden era of microbiology.
2. Isolation, purification and cultivation of microbes.
3. Important criteria used for classifications of microorganisms (morphological, ecological, biochemical, molecular and numerical).

Unit – II **10 Hours**

Bacteria:

4. Classification of bacteria based on Bergey's manual of determinative bacteriology.
5. Archaeobacteria and Eubacteria: Characters, Ultrastructure, nutrition, genetic recombination (Transformation, Transduction, Conjugation), and economic importance.
6. Cyanobacteria: salient features and biological importance.

Virus:

7. Biological nature, characteristics and ultrastructure of Plant, animal and bacterial virus, replication, transmission and economic importance of viruses.

Unit – III **10 Hours**

8. **Phytoplasma**: General characteristics, structure, reproduction and role in causing plant diseases.
9. General Structure, reproduction and importance of viroids, virusoids, prions and Retrovirus.

Unit – IV **10 Hours**

10. **Host-parasite interaction**: a brief idea of recognition and entry process of bacteria, viruses into animal & plant-host cells, alteration of host cell. Virus induced cancer; bacteria and plant two-component signaling systems; bacterial chemotaxis and quorum sensing. Hormones and their receptors, signaling through G–protein coupled receptors, regulation of signaling pathways.
11. **Innate and adaptive immune system**: Types of Immunity, antigens, antigenicity, structure and function of antibody molecules, monoclonal antibodies, Antigen-antibody interactions (serology), activation & differentiation of B and T Cell, B & T cells receptors, MHC molecules compliment system, immune response during bacterial (tuberculosis), parasitic (malaria) and Viral (HIV) infections, vaccine.

Unit – V **10 Hours**

12. Distribution of microbes in air, water, soil and human body.
13. Microbes for control of pollution.
14. Microbial enzymes and their applications.
15. Microbes in nanobiotechnology.

Course III: Biology and Diversity of Algae and Bryophytes 50 Hours

Unit – I 10 Hours

Algae:

1. Classification and salient features of different classes of Algae.
2. Algal pigments, food reserves, flagellation and their importance in classification.
3. Thallus organisation, reproduction and life cycle patterns.
4. Economic importance of algae as food, feed, source of chemicals and drugs, Algal biofertilizers, uses in industry and Algal blooms.

Unit – II 10 Hours

5. Comparative study of classes of Chlorophyceae, Xanthophyceae and Bacillariophyceae, with reference to:

a. Range of structure of plant body including ultrastructure.
b. Methods of reproduction.
c. Variation in life cycles.

Unit – III 10 Hours

6. Comparative study of Phaeophyceae and Rhodophyceae with reference to:
   a. Range of structure of plant body.
   b. Range of mode of reproduction.
   C. Variation in life cycles.

Unit – IV 10 Hours

Bryophytes:

7. Classification of Bryophytes and their distribution in India.
8. Range of thallus structure (plant body) and anatomy in Bryophytes (with suitable examples)
9. A general account of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales.

Unit – V 10 Hours

10. Evolutionary tendencies in sporophytes of Bryophytes (Progressive sterilization of sporogenous tissue)
11. Reproduction, life history, Inter-relationship, affinities of various groups of Bryophytes.
12. Ecology and economic importance of Bryophytes.

Course – IV: Biology and Diversity of Pteridophytes, Gymnosperms and Palaeobotany **50 Hours**

Unit – I **10 Hours**

Pteridophytes:

1. Classification of Pteridophytes; specific characters of important classes.
2. Salient features, comparative organography, systematics, reproduction and Phylogeny of the following:
   a. Psilopsida: Psilophytales (*Rhynia, Horneophyton*) and Psilotales (*Psilotum, Tmesipteris*).
   b. Lycopsida: Protolepidodendrales (*Protolepidodendron*), Lepidodendrales (*Lepidodendron, Stigmaria*), Lepidospermales (*Lepidocarpon*) and Isoetales (I*soetes*).
   c. Sphenopsida: Hyeniales (*Calamophyton*), Sphenophyllales (*Sphenophyllum*) and Calamitales (*Calamites*).
   d. Pteropsida: Coenopteridales — A general account. Ophioglossales (*Ophioglossum, Botrychium*), Marattiales (*Marattia, Angiopteris*), Osmundales (*Osmunda*), Filicales (*Cyathea, Dryopteris, Pteridium*), Marsileales (*Marsilea*), Salviniales (*Salvinia*, *Azolla*) and Indian Fossils.

Unit – II **10 Hours**

3. Telome concept.
4. Stelar system and evolutionary tendencies.
5. .Heterospory and evolution of seed habit.
6. Apogamy, apospory, parthenogenesis.
7. Soral evolution in Pteridophytes.
8. Alternation of generations.

Unit – III **10 Hours**

Gymnosperms:

a. Classification and distribution of gymnosperms with special reference to India. Study of morphology, structure and life history as illustrated by the following:Pteridospermales: Palaeozoic and Mesozoic group with reference to Lyginopteridaceae (*Lyginopteris*), Medullosaceae (*Medullosa*), Glossopteridaceae and Caytoniaceae.
b. Bennettitales: Cycadeoidaceae, Williamsoniaceae, Wielandiellaceae.
c. Cycadales: A detailed account including distribution *of living C*ycads.
d. Pentoxylale*s: A gene*ral account.
e. Cordaitales: A general account of Cordaitaceae and Poroxylaceae.
f. Ginkgoales: *Ginkgo*.
g. Coniferales: *Abies, Cedrus, Cryptomeria, Cupressus. Podocarpus, Cephalotaxus* and *Araucaria*.
h. Taxales: A general account.
i. Ephedrales, Welwitschiales and Gnetales: A general account.

Unit – IV **10 Hours**

10. Evolutionary tendencies in Gymnosperms.
11. Economic importance of Gymnosperms.

Unit – V **10 Hours**

Paleobotany:

12. Geological areas and distribution of plants in geological time scale.
13. Types of Fossils, Process of fossilization and fossil preservation methods.
14. Techniques of study of fossils.
15. Distribution of fossils in India

Course – V: Fungal Biodiversity and Elementary Plant Pathology 50 Hours

Unit – I 10 Hours

1. General characters of fungi, cell structure and nutrition.
2. Range of Thallus organization in fungi.
3. Unique aspects of (i) fungal cells, (ii) molecular biology of fungi
4. Types of reproduction in fungi.
5. Classification of fungi as proposed by Ainsworth (1973) Alexopoulus, Mims& Blackwell (1996).Recognition of Fungi as a separate kingdom; splitting of the fungi (Fungi and allied organisms into three kingdoms- Protista, Chromista and Fungi.
6. Nutrition and growth in Fungi including factors affecting fungal growth.
7. Differentiation in fungi: control of i) Dimorphism. ii) conidiation. iii) mating (with the help of Sex hormones).
8. Heterothallism, Heterokaryosis, parasexuality and physiological specialization in Fungi.

Unit – II 10 Hours

9. A general account and affinities of the following groups with special reference to systematic position, structure and reproduction of organisms mentioned hereunder:

I. The Fungi belonging to kingdom Protozoa:
a. Myxomycota (myxomycetes): *Stemonites, Ceratiomyxa*,
b. Plasmodiophoromycota (Plasmodiophorales) *Plasmodiophora*.
II. The Fungi belonging to Kingdom Chromista:
   a. Oomycota: Saprolegnia, Phythium, Phytopthora, Albugo,
III. The Kingdom Fungi:
a. Chytridiomycota: *Synchytrium*,
b. Blastocladiomycota: *Allomyces, Coelomomyces*
c. Zygomycota: *Saksanaea, Pilobolus, Entomophthora*
d. Ascomycota : *Taphrina, Phyllactinia, Erysiphae, Neurospora, Peziza*
e. Basidiomycota: *Puccinia, Uromyces, Hemiliea, Melampsora, Tilletia, Ustilago*
f. Anamorphic fungi (Deuteromycotina): With reference to their telomorph, also wherever possible; *Cercospora, Helminthosporium, Curvularia, Alternaria, Fusarium, Colletotrichum, Aspergillus, Penicillium*.

Unit – III 10 Hours

10. Fungal interactions: I. Role of antibiotics, hyphal interference,II. Mycoparasitism, III. Commensalism, Mycorrihizae, Lichens (Structure, types, reproduction, importance),
11. Fungi as biocontrol agents.
12. Symptoms of fungal, bacterial and viral plant diseases.
13. Causes of plant diseases.
14. Host-parasite relationship, role of enzymes and toxins in disease development.
15. Effect of infection on physiology of host.
16. Effect of environment on disease development-epiphytotics.

Unit – IV 10 Hours

17. Disease control by Physical methods, chemical methods, crop rotation, plant quarantines, resistance
18. Integrated pest management mechanism, its advantages, disadvantages and future prospects.

19. Principles of biological control of air- borne and soil-borne plant diseases.

Unit – V **10 Hours**

23. Etiology and control of the following crop diseases:

Paddy : Paddy blast, Bacterial leaf blight.
Wheat : Black Stem rust, Bunt of wheat, Flag smut.
Jowar : Grain Smut.
Sugercane : Smut, Red rot.
Cotton : Wilt
Grape : Downy and powdery mildew
Apple : Apple scab
Groundnut : Tikka disease.
Fibre : Rust of *Linum*.
Coriander : Gall of coriander.

Course VI : Cell and Molecular Biology of Plants **50 Hours**

Unit – I **10 Hours**

1. The Dynamic cell: Structural organization of plant cell, specialized plant cell.
2. Microscopy: Principle, parts and functioning of electron microscopes including stereoscopic binocular, dark field illumination, confocal, phase contrast, fluorescence and polarizing microscopes, camera lucida, SEM, TEM. STEM.
3. Cell envelopes: Ultra-structure, chemical foundation and functions of cell wall, Biological membranes with special emphasis on plasma membrane and tonoplast membrane.

Unit – II **10 Hours**

4. Plant Cell inclusions, their structure and function; Mitochondria and Chloroplast.
5. Nucleus & Nucleolus: Structure, nuclear pores, nucleosome concept.
6. Chromatin Organisation: Chromosome structure and composition, Centromere, Telomere, Euchromatin and Heterochromatin, Karyotypes, Polytene, Lamp brush chromosomes and Sex chromosomes.

Unit – III **10 Hours**

7. Ribosomes, Dictyosomes, Lysosomes, ER, Microbodies and Plasmodesmata.
8. Cell cycle & Apoptosis: Biochemical and genetic mechanism–
   a) Mitosis, spindle formation mechanism, cytokinesis, cell plate formation, Cytoskeleton with emphasis on spindle apparatus, motor movements.
   b) Meiosis and its significance
   c) Programmed Cell Death (PCD).

Unit – IV **10 Hours**

9. Nucleic Acids: Nature, Structure, types of DNA (A, B, Z-DNA) and RNA, (t-RNA, micro-RNA) difference between DNA & RNA; DNA replication (Origin and fork) and its biosynthesis, extra chromosomal replications, DNA damage and repair, transposons and mechanisms of transposition.
10. Genetic Code: Discovery, Properties and cracking of genetic code.

Unit – V **10 Hours**

11. Protein Synthesis: Basics, mechanism of protein synthesis in prokaryotes and eukaryotes, transcription, RNA processing, reverse transcription, translation and regulation of protein synthesis in prokaryotes (Structural, regulatory genes and operon model).
12. Control of gene expression at transcription and translation level: Regulation of gene expression in phages, viruses, prokaryotes and eukaryotes, role of chromatin in regulating gene expression and gene silencing.

Course – VII: Genetics, Cytogenetics and Plant Breeding **50 Hours**

Unit – I **10 Hours**

Genetics:

1. Mendel's Laws of inheritance and modified ratios.
2. Allelic and non allelic interaction of genes.
3. Multiple alleles: alleles, coat colour in rodents, blood groups in Humans, self incompatibility.

Unit – II **10 Hours**

4. Linkage and crossing over: chromosome mapping, linkage groups, mechanism of chromosome pairing and synaptonemal complex.
5. Sex determination in man, Drosophila and plants.
6. Maternal effects and Extra- nuclear inheritance.

Unit – III **10 Hours**

7. Biochemical genetics, concept of gene.
8. Structural changes in chromosomes: Deficiency, duplication (meiotic pairing & phenotypic effects), Inversions, translocations, (meiotic pairing, Chromosome disjunction), multiple translocations.
9. Numerical changes in chromosomes and Haploidy:

a) Euploidy/Polyploidy : Classification, production, role in evolution, utility in crop improvement.

b) Aneuploidy : Trisomics, tetrasomics, monosomy, multisomy- meiotic behaviours, breeding behaviour.

c) Apomixis : Cytogenetic basis and types of Apomictic reproduction

Unit – IV **10 Hours**

10. Mutation: Types of mutations, spontaneous and induced mutations, Physical and chemical mutagens, gene mutations, induction and detection of mutation, mutation by transposons.
11. Concept of gene: gene structure and expression; gene fine structure, cis-trans test, Biochemical genetics, introns.

Unit – V **10 Hours**

Plant breeding:

12. Methods of plant breeding.
13. Genetic basis of inbreeding, hybridization and heterosis, exploitation of hybrid vigour.
14. Plant breeding work done in India with special reference to potato, maize, rice, wheat, sugarcane and cotton.

Course VIII : Anatomy and Reproduction in Angiosperms 50 Hours

Unit-I 10 Hours

Plant Anatomy:

1. Shoot development: organisation of shoot apical meristem (SAM), Cytological and molecular analysis, Leaf (Marginal meristem).
2. Root development: organisation of root apical meristem (RAM), Cell fates and lineage differentiation of vascular tissue, regulation of root growth.

Unit – II 10 Hours

3. Epidermal structures, ontogeny and classification of stomata, trichomes and secretory glands
4 Phloem: Structure and development of sieve elements, P-Proteins.
5. Xylem: Structure and development of tracheary elements.
6. Vascular cambium: normal and abnormal functioning.
7. Nodal Anatomy: evolution of nodal vasculature.

Unit - III 10 Hours

Embryology:

8. Formation of floral organs: floral development molecular basis of floral organ determination. Morphology of stamen, carpel and placentation, (MADS Box) Homeotic genes.
9. Megasporangium (ovule): Structure and development.
10. Female gametophyte: Megasporogensis, organisation and types of embryo sac, gene function during megagametogenesis, ultra structure of embryo sac.
11. Anther: Structure, microsporogenesis, tapetum, pollen development, including pollen wall, pollen germination and pollen tube growth, development of male gametophyte, palynology and its applications.

Unit – IV 10 Hours

12. Pollen-Pistil interactions, Pollination mechanism and vectors, double fertilization.
13. Sexual Incompatibility: its genetic basis, molecular aspects, physiology and biochemistry. Barriers to fertilization, methods to overcome incompatibility.

Unit – V 10 Hours

14. Polyembryony: causes, classification and applications.
15. Endosperm: development, types, haustoria, mosaic endosperm, ruminate endosperm, xenia, metaxenia.
16. Embryogenesis: nutrition and growth of embryo; development of dicot and monocot embryos.
17. Fruit growth and development: with special reference to legumes and cucurbits.
18. Seed anatomy
19. Apomixis and Parthenocarpy: types and importance.

Course IX : Plant-Soil-Water Relations & Growth and Development 50 Hours

Unit – I 10 Hours

Soil - water-plant relations:

1. Functional aspects of plant cell structure: colloidal systems, Water as a universal solvent,pressures and potentials.
2. Active and passive absorption of water. Factors affecting water absorption
3. Role of micro and macro mineral nutrients, their physiological functions and deficiency symptoms, Hydroponics.
4. Mechanism of ion (mineral) absorption. Factors affecting mineral absorption.

Unit – II 10 Hours

5. Driving forces and resistances in transpiration; stomatal movement mechanism.
6. Ascent of sap, Translocation of solutes in plants; sensor- regulator system, sucrose sensing mechanism.
7. Stress Physiology: Plant response to biotic and abiotic stress, mechanism of stress tolerance, HR and SAR, water deficit and drought resistance mechanism of salinity, metal toxicity, freezing heat and oxidative stress resistance,

Unit – III 10 Hours

Growth & Development:

8. Discovery, chemical structure, physiological role, mechanism of action, bioassay and practical applications of following plants hormones:

a. Auxins
b. Gibberellins
c. Cytokinins

9. Hormone receptors, cell signaling and Signal transduction

Unit – IV 10 Hours

10. Elementary idea of structure and functions of ABA, Ethylene, Ascorbic Acid, Brassinosteroids, Polyamines, Jasmonic acid and Salicylic acid.
11. Sensory photobiology: detection structure, chemistry, physiology, function and mechanism of action of phytochromes, cryptochromes and phototropins.
12. Photoperiodism; Photoinduction and vernalization, Role of florigen, vernalin, phytochrome and C/N ratio in flowering.

Unit – V 10 Hours

13. Dormancy: Dormancy of seeds and buds, gene expression during dormancy.
14. Seed germination and seedling growth, metabolism of nucleic acid, mobilization of reserved food material, hormonal control of seedling growth, gene expression during seedling growth.
15. Endogenous rhythms
16. Plant movements
17. Ageing and Senescence

Course X : Phytochemistry and Metabolism 50 Hours

Unit- I 10 Hours

Energy flow:

1. Fundamentals of thermodynamics and bioenergetics
2. Buffers, pH Scale, redox potential
3. Structure and functions of ATP;
4. Forces stabilizing macromolecules

Unit – II 10 Hours

Fundamentals of Enzymology:

5. Classification, mechanism of enzyme action and catalysis, Allosteric mechanism, active sites, isoenzymes, Coenzymes, steady state enzyme kinetics, Michaelis - Menten equation and its significance.
6. Conformation of proteins: secondary, tertiary and quaternary structure; domains; motif and fold, Ram Chandran's Plot
7. Protein catabolism: Lysosomal and ubiquitin targeted proteolysis.

Unit – III 10 Hours

Photochemistry and Photosynthesis and Carbohydrate Metabolism:

8. General concept, Photosynthetic apparatus, Photosynthetic cycle, pigments, light harvesting and non-cyclic complexes, Photo-oxidation of water, electron and proton transport, Photophosphorylation.
9. Carbon assimilation – the calvin cycle (C_3 cycle), Photorespiration and its significance, the C_4 cycle, the CAM pathway, biosynthesis of starch and sucrose, physiological and ecological considerations.

Unit – IV 10 Hours

Respiration and fatty acid metabolism:

10. Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, oxidative phosphorylation; coupled reaction group transfer biological energy transducers,
11. Pentose phosphate pathway, glyoxylate cycle, alternative oxidase system;
12. Structure and function of fatty acids, biosynthesis and their catabolism.

Unit – V 10 Hours

Nitrogen and sulphur metabolism:

13. Overview of biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, nucleotide metabolism.
14. Sulphur uptake, transport and assimilation.

Secondary metabolites:

15. Elementary idea of secondary metabolities like alkaloids, lignin and phenolics (terpenes, phenols) with emphasis on flavonoids.

Course XI : Plant Ecology and Phytogeography 50 Hours

Unit – I 10 Hours

1. Ecological factors (light, air, water, topographic, edaphic, biotic)
2. Ecological concepts of species: Genecology and Ecological niche.
3. Population Ecology: Basic concepts, characteristics of population and population structure.
4. Community Ecology: Composition, characters, structure, origin and development of community: methods of study of structure of community.

Unit – II 10 Hours

5. Ecological succession: Process concept and trends. Climax. (Xerosere, hydrosere)
6. Ecosystem Ecology: Structure and functions, with example of a natural and artificial ecosystem, Energy flow in ecosystem.
7. Production Ecology: Measurement methods and productivity in different ecosystems.

Unit – III 10 Hours

8. Preliminary Knowledge of I.B.P. (International Biological Programme), M.A.B (Man and Biosphere Programme).
9. Pollution: Kinds of pollution (Air, Water, Soil and Noise) and green house gases, Ozone hole, and global warming.

Unit – IV 10 Hours

10. Recycling of waste: Biogas, utilization and disposal of organic wastes and inorganic wastes,
11. Biodiversity and It's conservation.
12. Biogeochemical cycles of C,N,P,S, and Hydrological cycle, Nutrient sources, Nutrient budgets in terrestrial communities and aquatic communities.
13. Soil erosion and conservation, rainwater harvesting, chipko movement, van mahotsava, Afforestation, reforestation.

Unit – V 10 Hours

Phytogeography

14. Principles of phytogeography, vegetation types and Phytogeographical regions of India. Age and area hypothesis, continental drift, endemism, Hot spots, Plant exploration. Invasion and introduction.
15. Remote sensing: Concepts, principles, processes, tools, techniques in acquisition of R.S. data. Application in ecological and meteorological research

Course XII: Elementary Biotechnology 50 Hours

Unit – I 10 Hours

1. Definition, Basic concepts, Principles and scope of Biotechnology.
2. Recombinant DNA technology, basic concept in genetic engineering, tool and techniques of recombinant DNA technology.
3. Enzymology of genetic engineering: Restriction enzymes, DNA ligase, Polymerase etc.

Unit – II 10 Hours

4. Cloning vehicles: Plasmids, Cosmids, Lambda phage, Charon phage, shuttle vectors, 2μ DNA plasmids, yeast plasmids.
5. Gene cloning: principles and techniques, choice of vectors, DNA synthesis and sequencing, Analysis and expression of cloned genes in host cells, Polymerase chain reaction (PCR), RFLP, DNA finger printing (Southern and Northern blotting), gene therapy, Genetic counselling.
6. Gene libraries: mRNA isolation, cDNA synthesis, cloning and amplification of gene libraries, Genomic DNA libraries, YACs, BACs Transposable elements, techniques of gene mapping and chromosome walking.

Unit – III 10 Hours

7. Transgenic (Genetically modified) Plants: Genetic engineering of plants, Aims, strategies for development of transgenic plants (with suitable examples, *Agrobacterium* – the natural genetic engineer, T-DNA and transposon mediated gene-tagging, chloroplast mediated transformation and its utility,
8. Intellectual Property Right (IPR), possible ecological risk and bioethics.

Unit – IV 10 Hours

9. Plant cell and Tissue culture: General introduction, history, scope, cell and tissue culture techniques.
10. Design and functioning of tissue culture laboratory.
11. Cell proliferation measurements, cell viability testing, culture media preparation and cell harvesting methods, concepts of cellular differentiation and totipotency.

Unit – V 10 Hours

12. Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitation of protoplast research.
13. Application of plant tissue culture: clonal propagation, artificial seed, production of hybrids and somaclones, organ culture, production of secondary metabolites, natural products, cryopreservation and germplasm conservation.

Course XIII: Modern Phytotechniques and Biostatistics 50 Hours

Unit I 10 Hours

Basic Botanical techniques:

1 Different types of stains, their preparation and uses: Safranin, fast green, hematoxylin, iodine, cotton blue, crystal violet, ruthenium red, Janus green, Gram's stains, Acetocarmine

2. Microtomy: dehydration, clearing and embedding of material, section cutting, dewaxing.
3. Collection and preparation of herbarium sheets; preservation and storage of plant materials

Unit II 10 Hours

Biophysical methods

4Instrumentation, principle and Methods of fractionation- Cell sorting, Chromatography, Electrophoresis, Centrifugation, X- ray diffraction

Unit III 10 Hours

Methods of quantitative analysis-

1. Spectrophotometry, MS, NMR, ESR, ORD/CD spectrometers,
2. Radioisotopic methods: Geiger Muller & Liquid Scintillation Counters.
3. Immunological methods: immunodiffusion, immuno- electrophoresis, crossed immuno-electrophoresis, counter- RIA, ELISA , Immunoblotting

Unit IV 10 Hours

Statistical methods

1. Classification and presentation of data, , graphical presentation: frequency polygon and curve, &cumulative frequency curve. Distribution
2. Measures of Central tendency: mean, mode, median and their properties .
3. Measures of dispersion: Mean deviation, standard deviation and coefficient of variation.

Unit V 10 Hours

11. Simple correlation, coefficient and regression,
12. Principle of experimental designs, randomized block and latin square designs and analysis of variance (ANOVA).
13. Tests of significance, t-tests, X^2 test for goodness of fit.

Course XIV: Biodiversity Conservation and Plant Resources 50 Hours

Unit - I 10 Hours

1. Biodiversity: Definition; factors responsible for determination of Biodiversity;
2. Global concern over climate change.
3. Levels of Biodiversity: Genetic, Species, Ecological, Evolutionary and Agrobiodiversity.
4. Diversity Measures: (Diversity Indices)- Alpha(α), Beta (β), Gamma(γ) Diversity.

Unit - II 10 Hours

5. Biodiversity Conservation Initiatives

a) *In situ* Stratagy : National parks, Wild life sanctuaries, biosphere reserves and world heritage sites.

b) *Ex-situ* Stratagy : By seeds, reclamation, Afforestation, tree Plantation, seed banks, gene banks, cryobanks

c) General account of activities of BSI, NBPGR for conservation and non-formal conservation efforts

d) Restoration or Rehabilitation of Endangered species.

Unit - III 10 Hours

6. Biodiversity at world level: Biodiversity at global and country level, wild plant wealth.
7. Ecosystem diversity in India: Desert, forest, Grassland ecosystem, wetland, Mangroves.
8. Species Diversity: Endemic species, cultivated plants/Agro- diversity, Endangered plants.

Unit - IV 10 Hours

9. Loss of Biodiversity:

a) Causal factors – Developmental pressure, encroachment, exploitation, human induced and natural floods, earthquake, cyclone, landslides, Disaster management.

b) Threat to Ecosystem, species and genetic Diversity.

Categories of threats : Endangered, Vulnerable, Rare and Threatened

Unit - V 10 Hours

10. Plant resources, Concept, Status and Concern
11 Basic concepts of local plant diversity and its economic importance
12. World centres of primary diversity of domesticated plants
13. Biodiversity protection laws and policies, management of natural resources.

ELECTIVE COURSES

Course XV: Recombinant DNA Technology **50 Hours**

Unit – I **10 Hours**

1. Genetic Engineering – Definition and explanation, restriction enzymes and restriction modification system.
2. Cloning and expression vectors – Definition and explanation: plasmids, cosmids, phagemids, fd, fl, and M13 vectors, transposons vectors.
3. Artificial chromosomes as vector.
4. Expression vectors; Use of promotors and expression cassettes, Virus expression vectors, binary and shuttle vectors.

Unit – II **10 Hours**

5. Reconstruction of chimeric DNA – staggered cleavage, addition of Oligopolymer tailing, blunt end ligation.
6. Cloning in bacteria vs. cloning in Eukaryotic cells.
7. Preparation of molecular probes and their uses; labeling of probes, radioactive vs non-radioactive. Techniques used in probing DNA, RNA & Protein electrophoresis, Southern, Northern and Western blotting.
8. Techniques of restriction mapping.

Unit – III **10 Hours**

9. Polymerase chain reaction – Principles, techniques and modification, gene cloning vs. PCR, application and uses of PCR.
10. Chromosome walking, Chromosome jumping, Chromosome landing, map based cloning.
11. Compliment DNA, its cloning and cDNA library.

Unit – IV **10 Hours**

12. RFLPs & RAPD and their applications.
13. Gene sequencing.

Unit – V **10 Hours**

14. Protein Engineering- definition and explanation, Steps involved, methods used, Achievements and future prospectus.
15. Drug designing – methods used, blocking enzyme activity, blocking hormones receptors, inhibition of DNA/RNA synthesis.
16. Chemical synthesis vs recombinant DNA technology in protein engineering and drug designing.

Course XVI: Plant Cell, Tissue and Organ Culture 50 Hours

Unit – I 10 Hours

1. Planning and organization of tissue culture laboratory; Basic techniques of plant tissue culture.
2. Induction and maintenance of callus and cell suspension culture.
3. Study of differentiation through organogenesis and embryogenesis.

Unit – II 10 Hours

4. Cell line selection through suspension culture for the production of stress resistant plants, their application in crop improvement.
5. Tissue culture techniques for haploid production and their application in agriculture.
6. Meristem culture for mass and clonal propagation of ornamental plants, virus resistant plants and forests trees.

Unit – III 10 Hours

7. In-vitro Pollination, shotgun wedding, embryo rescue technique and embryo culture.
8. Encapsulation of somatic embryos and shoot apices for artificial seeds.
9. Cryopreservation techniques for germplasm conservation.

Unit – IV 10 Hours

10. Protoplast isolation, culture and regeneration.
11. Somatic hybridization and selection mechanism for hybrids and cybrids, with special reference to crop plants.
12. Delivery systems for gene transfer in plant through co-cultivation of explants and *Agrobacterium* or thorough direct methods-electroporation, silicon carbide method.

Unit – V 10 Hours

13. Transgenic plants: Use of transgene for – herbicides, insecticides, virus, drought, salinity and insect resistance; male sterility and restoration systems, molecular forming.
14. Industrial application of plant tissue culture for:

i) Secondary metabolism for commercial purpose.
ii) Scale up and down stream processing for secondary metabolites.

Course XVII: Microbial Biotechnology 50 Hours

Unit – I 10 Hours

1. Sources and characters of industrial microbes, their isolation and methods for induction of mutations; stabilization of mutants and their isolation.
2. Fermentation technology; microbial growth, application of fermentation; batch, fed batch and their continuous cultures of microbes.
3. Patent protection for biological inventions.

Unit – II 10 Hours

4. Bioreactors: Principles and their design.
5. Microbial transformations with special reference to steroids and alkaloids, polysaccharides.

Unit – III 10 Hours

6. Microbiology and up gradation of alcoholic beverages.
7. Commercial production of organic acids like acetic, lactic, citric and gluconic acids.
8. Commercial production of important amino acids, insulin, steroids, vitamins and perfumes.
9. Commercial production of antibiotics with special reference to penicillin, streptomycin and their derivatives.

Unit – IV 10 Hours

10. Immobilization of microbial enzymes and whole cells and their applications in industries.
11. Use microbes in food, feed and dairy; Bioprocess engineering; Down stream processing, various steps for large-scale protein purification.
12. Single cell proteins, physiological aspects, SCP from hydrocarbons, waste materials and renewable resources, improvement in SCP production.
13. Industrial sources of enzymes; Cellulases, Xylanases, Pectinases, Amylases, Lipases, and Proteases, their production and applications.

Unit – V 10 Hours

14. Bioconversion of waste for fuel and energy.
15. Petroleum Microbiology
16. Commercial production of biofertilizers and biopesticides.

Course XVIII: Biotechnology- II: Environmental Biotechnology 50 Hours

Unit – I 10 Hours

1. Pollution and Pollutants: Cost of pollution, Kinds of Pollution and Pollutants- Air, Water, and Soil Pollution, Their effects on Plants and Ecosystems;
2. Role of Plants in Pollution Management.

Unit – II 10 Hours

3. Climate Change: Greenhouse Gases (CO_2, CH_4, N_2O, CFCs: sources and roles), Ozone layer and Ozone hole, Consequences of Climate change (acid rain, global warming, sea level rise, UV radiation).

Unit – III 10 Hours

4. Ecosystem Stability: Concept (resistance and resilience), Ecological Perturbations (natural and anthropogenic) and Their Impacts on Plants and Ecosystems, Ecology of Plant Invasion, Environmental Impact Assessment (EIA), Ecosystem Restoration.
5. Environment and energy, Energy resources – Renewable and Non-renewable. Natural resources, Loss of Diversity, causes and consequences, Environmental Auditing, Conservation of Biodiversity.

Unit – IV 10 Hours

6. Ecological Management: Concepts, Sustainable Development, Remote sensing and GIS as Tools for Resources Management.

Unit – V 10 Hours

7. Phytoremediation: Prevention and Control, Methods of reducing Environmental impacts of Chemicals, Weedicides, Pesticides and Fertilizers. Biotechnological advances in pollution control through GEMs.

Course XIX: **Stress Physiology of Plants** **50 Hours**

Unit-I **10 Hours**

1. Biological stress vs. Physical Stress, Types of stresses and general methods of measurement of stress response (Strain),
2. Stress physiology in crop improvement
3. Response to UV stress: Injury and resistance mechanism

Unit- II **10 Hours**

4. Response to low temperature stress: Chilling, freezing, frost injury and mechanism of resistance, Adaptations
5. Response to high temperature stress: Injury and mechanism of resistance, Heat shock proteins, Adaptations

Unit –III **10 Hours**

6. Response to nutrient deficiency stress
7. Heavy metal stress, injury and mechanism of resistance, adaptations
8. Salinity stress, Ionic and salt stress injury, mechanism of resistance

Unit-IV **10 Hours**

9. Response to water deficit: Desiccation, Dehydration injury; Mechanism of resistance, Adaptations
10. Response to water excess: Flooding, hypoxia, Mechanism of resistance, Adaptations

Unit-V **10 Hours**

11. Causative agents for Biotic Stresses
12. Mechanism of Resistance against Fungal, Bacterial and viral pathogens

Course XX: **Applied Plant Physiology** **50 Hours**

Unit –I **10 Hours**

Crop Productivity

1. Role of crop physiology in agriculture,
2. Crop growth and productivity, phenology-crop productivity, growth factors related to biomass - concept of growth rates- canopy photosynthesis (leaf area and net assimilation rates as determining factors).
3. Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis.

Unit-II **10 Hours**

Physiology of Crop species

4. Concept of source and sink, factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages.
5. Growth and development of crop species. Juvenility, shoot growth, types of shoots, patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing.
6. Growth measurements. Water relations of tree species, water uptake and transport. Concepts of transpiration rate and water use efficiency. Sexual and asexual propagation.
7. Rootstock and scion interactions.

Unit-III **10 Hours**

Post-Harvest Physiology

8. Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence.
9. Gene expression during senescence.
10. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds.

Unit-IV **10 Hours**

11. Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest life of cut flowers.
12. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport.
13. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life.

Unit-V **10 Hours**

Chemistry of Plant Production Chemicals

1. Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc.), production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquidfertilizers, biofertilizers, integrated plant nutrient systems.
2. Nutrient use efficiency (principles and approaches). Soil conditioners and amendments.

Course XXI: Diversity in Plants, their origin and evolution 50 Hours

Unit – I 10 Hours

Sustainable Development:

1. Global movement for sustainability
2. People's mandate on sustainable development
3. Strategies for sustainable development
4. Contribution of telecommunication and information technology to sustainability
5. Social perspectives for sustainable development
6. Political perspectives for sustainable development
7. Concept of circular economy

Unit – II 10 Hours

Origin of Agriculture :

8. Meaning of Agriculture, Development of Agriculture
9. Origin of cultivated plants, Indo-Burmese Centre of Origin,
10. Contribution of Vavilov,
11. Domestication of crop plants
12. Plant introduction

Unit - III 10 Hours

Green revolution:

13. Benefits and adverse consequences, beyond green revolution
14. Plants as Avenue trees: Selection of avenues and avenue trees, planting schemes
15. Plants as Pollution control agents: Tolerance of plants to different pollutants

Unit - IV 10 Hours

Origin, evolution and cytotaxonomy of

16. Cereals and millets (wheat, paddy, bajra and jowar),
17. Legumes (peas, gram, soybean, black gram, lentil and cowpea),
18. Sugarcane and starches (beetroot, potato, sweet potato,),
19. Origin of Forage and fodder crops.

Unit - V 10 Hours

20. A general account of non-wood forest products (NWFPs) such as bamboos, gum, tannins, dyes, resins and beverages.
21. A general account of the organizations and functions of Indian Council of Agricultural Research (ICAR). Council of Scientific and Industrial Research (CSIR) and the Department of Biotechnology (DBT)

Course XXII: Elementary Knowledge of Computers and Bioinformatics 50 Hours

Unit –I 10 Hours

1. Computer System- Definition; Components (Input/Output unit, Control Unit., Primary Storage Unit, Arithmetic and Logic Unit); Types of Memory, Generation of Computers
2. Number System & Logic Gates- Application of Number Systems (Decimal Number System, Binary Number System, Hexadecimal Number System) & Conversions (Decimal to Binary, Binary to Decimal, Decimal to Hexadecimal, Hexadecimal to Binary); Addition operation in Binary Number System; Introduction to Logic Gates(AND, OR, NOT, NAND, NOR, XOR XNOR); Introduction to Software.

Unit- II 10 Hours

3. Bioinformatics - Introduction; Definition & Concept, Role of Bioinformatics, Introduction of Internet in Biology & objectivity, Services of Internet used for Biological Data, Human Genome Project.

Unit- III 10 Hours

4. Database System- Definition; Purpose of Database System; Advantages of Database System, Relational Database- Definition; Relational Data Model, Database- Primary Databases & Secondary Databases, Sequence Databases(EMBL, GenBank, DDBJ, SWISS-PROT, PIR, TrEMBL), Protein Family/Domain Databases (PROSITE, Pfam, PRINTS & SMART)

Unit- IV 10 Hours

5. Sequence comparison algorithm, Dynamic programming, Dot plot matrix, sequence scoring schemes (weight matrix as Identify scoring, genetic code scoring scheme chemical scoring, observed Substitution matrix and Gap penalties),Sequence database similarity searching algorithms, local alignment, global alignment, FAST A, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX) and similarity searching scores and their statistical interpretation

Unit-V 10 Hours

6. Motifs and Domains, algorithm for multiple alignments, Biological motifs, micro array, Phylogenetic prediction: Relationship of Phylogenetic analysis to sequence alignment, Genome complexity and phylogenetic analysis, concept of evolutionary trees. Maximum parsimony method, distance method, maximum likelihood method

Course XXIII: PLANT PATHOLOGY 50 Hours

Unit 1: 10 Hours

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection, colonization and development of symptoms. Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Methods of inoculation. Measurement of plant disease. Molecular detection of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA and PCR.

Unit 2: 10 Hours

Mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinants. Enzymes and toxins in relation to plant disease. Mechanisms of resistance. Phytoalexins. PR proteins. Antiviral proteins. SAR. HR and active oxygen radicals. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, hypovirulence, cross protection/useful genes and promoter technology, biosafety and bioethics.

Unit 3: 10 Hours

Fungal diseases of crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management (Ergot of rye, Early blight of potato, Soft rot of sweet potato, Downy mildew of cereals, Brown spot of rice, Leaf spot of oat, Wilt of gram, White rust of crucifers, Club root of brassica, Fruit rot of chillies, Fruit rot of tomato, Rust of linum, Powdery mildew of Dalbergia, Black mold rot of onion, Wilt of chick pea). Post harvest diseases in transit and storage; aflatoxins and their integrated management.

Unit 4: 10 Hours

Diseases of crop plants caused by bacteria, viruses, viroids, phytoplasmas (Angular leaf spot of cotton, Potato scab, Soft rot of potato, Citrus canker, Crown gall of apple, Fire blight of apple, Tundu disease of wheat, Ear rot of wheat, Gummosis of sugarcane, Papaya mosaic/ringspot, Yellow vein of ladyfinger, Potato spindle tuber, Little leaf of brinjal). Mode of transmission and pathogen vector relationships. Epidemiology and management.

Unit 5: 10 Hours

General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Genetic basis of disease resistance and pathogenicity: gene for gene hyphothesis; breeding for disease resistance. Production of disease free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassay and compatibility with other agricultural chemicals; resistance to fungicides/ antibiotics; effect on environment. Spraying and dusting equipments, their care and maintenance. Important cultural practices and their role in disease management, solarization, integrated disease management (IDM). Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere microbes and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria (PGPRs).