Name of programme: B.Sc. (Botany Hons.)

Programme outcomes

1. Understanding of Plant Biology: Graduates will have a comprehensive understanding of plant biology, including plant anatomy, physiology, genetics, ecology, and taxonomy.

2. Research Skills: Students will develop strong research skills, including the ability to design experiments, collect and analyze data, and draw conclusions based on scientific evidence.

3. Critical Thinking: Graduates will be adept at critically analyzing scientific literature, evaluating hypotheses, and forming independent conclusions based on evidence.

4. Laboratory Techniques: Students will gain proficiency in a range of laboratory techniques commonly used in botany, such as microscopy, tissue culture, DNA extraction, and chromatography.

5. Fieldwork Experience: The program will provide opportunities for students to engage in fieldwork, allowing them to apply theoretical knowledge in real-world settings and develop practical skills in plant identification, ecosystem analysis, and environmental monitoring.

6. Communication Skills: Graduates will be able to effectively communicate scientific concepts and findings through written reports, oral presentations, and visual media.

7. Ethical Awareness: Students will develop an understanding of the ethical considerations and responsibilities involved in botanical research and practice, including issues related to biodiversity conservation, biotechnology, and sustainable agriculture.

8. Interdisciplinary Knowledge: The curriculum may include interdisciplinary topics that integrate botany with other fields such as environmental science, biochemistry, biotechnology, and agriculture, preparing students for diverse career paths or further study.

9. Problem-Solving Abilities: Graduates will be equipped with problem-solving skills applicable to various challenges in botany and related fields, such as crop improvement, environmental conservation, and natural resource management.

10. Professional Development: The program may include opportunities for professional development, such as internships, seminars, and workshops, to prepare students for careers in academia, industry, government, or non-profit organizations.

11. Adaptability and Lifelong Learning: Students will develop the ability to adapt to new technologies, methodologies, and research findings in the rapidly evolving field of botany, fostering a commitment to lifelong learning and professional growth.

These outcomes equip graduates with the knowledge, skills, and attitudes necessary to pursue successful careers in botany and related fields, as well as to contribute to scientific discovery, environmental stewardship, and sustainable development.

Semester I

CC1: Phycology and Microbiology
(Credits: Theory-4, Practical-2)

THEORY

Unit1: Introduction to microbial world – Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 2: Viruses – Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).

Unit 3: 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).

Unit 4: 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; methods of reproduction; Classification; criteria, system of Fritsch, and evolutionary classification of Lee (only upto groups); Significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar). Role of algae in the environment, agriculture, biotechnology and industry.

Unit 5: Cyanophyta and Xanthophyta – Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of *Nostoc* and *Vaucheria.*

Unit 6: Chlorophyta and Charophyta – General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete, Chara.* Evolutionary significance of *Prochloron.*

Unit 7: Phaeophyta and Rhodophyta – Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus*, *Fucus* and *Polysiphonia.*

COURSE OUTCOMES

Students will learn:

- Microbial world, types of microbes, microbial diversity including algae, their growth pattern, nutritional behaviors, their importance in relation to agriculture and industry.
- Structure of viruses, their multiplication process.
- Structure, types of bacteria, and their replication process.
- Characteristics of algae including structure, distribution, their classification, and importance.
- Structure, occurrence, pigments and life cycle of different algal genera belonging to different classes.

PRACTICAL

Microbiology

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

Phycology

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

COURSE OUTCOMES

Students will be able:

- To identify viruses (T-phage and TMV) and know the life cycle/multiplication of virus with the help of pictures/photographs.
- To observe microbes/bacteria under microscope and also know about binary fission, endospore, conjugation and root nodule.
- To identify bacteria by gram staining and malachite green methods.

Core Course II: Biomolecules and Cell Biology
(Credits: Theory-4, Practical-2)

THEORY

Unit 1: Biomolecules – Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

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

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

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

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

Unit 3: Enzymes – Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

Unit4: The cell – Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 5: 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.

Unit 6: Cell organelles – Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

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

Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins aand lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.

Unit 7: Cell division – Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

COURSE OUTCOMES

Students will learn:

- The concept of biomolecules, important biomolecules, pH and buffers and their roles in biochemical reactions.
- Bioenergetics controlling the turnover/metabolism of biomolecules.
- Enzymes, their types, role, and mechanism of actions.
- Cell structure, types, cell division, and cellular organelles, and their functions.

PRACTICAL

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo/Crinum.*
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Measurement of cell size by the technique of micrometry.
5. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
6. Study of cell and its organelles with the help of electron micrographs.
7. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
8. Study the phenomenon of plasmolysis and deplasmolysis.
9. Study the effect of organic solvent and temperature on membrane permeability.
10. Study different stages of mitosis and meiosis.

COURSE OUTCOMES

Students will be able:

- To know the carbohydrates, lipids and proteins by simple qualitative tests.
- To know about the basic structure of plant cells, their divisions (mitotic and meiotic), protoplasmic streaming, plasmolysis, deplasmolysis, effects of organic solvent and temperature on membrane permeability.
- To measure the cellular dimension under microscope, and count the cells by haemocytometer
- To differentiate the DNA from cytoplasm by staining techniques.

Semester II

CC III: Mycology and Phytopathology
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Introduction to true fungi – General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification.

Unit 2: Chytridiomycota and Zygomycota – Characteristic features; Ecology and significance; Thallus organisation; Reproduction; Life cycle with reference to *Synchytrium, Rhizopus* .

Unit 4: Ascomycota – General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; Life cycle and classification with reference to *Saccharomyces, Aspergillus*, *Penicillium, Alternaria, Neurospora* and *Peziza.*

Unit 5: Basidiomycota – General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 6: Allied Fungi – General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

Unit 7: Oomycota – General characteristics; Ecology; Life cycle and classification with reference to *Phytophthora, Albugo.*

Unit 8: Symbiotic associations – Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 8: Applied Mycology – Role of fungi in biotechnology; Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit 9: 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 of cotton. Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers.

COURSE OUTCOMES

Students will learn:

- General characteristics of a true fungi, structure, thallus organization, nutrition and classification.
- Characteristics, thallus organization, reproduction, lifecycle, ecology and significance of Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota & Oomycota.
- General characteristics of allied fungi.
- Symbiotic association with reference to General characteristics and significance of lichen and mycorrhizae.
- Role of fungi in Biotechnology, food industry, medicine and agriculture; Mycotoxins.

- Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases.; Bacterial diseases, viral diseases, fungal diseases

PRACTICAL

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

COURSE OUTCOMES

Students will:

- Learn about the complexity of organisation of fungal plant body practically.
- Be able to identify and know the genera of fungi belonging to different classes, their morphology, life cycle and spore types.
- To identify some important pathogenic fungi like *Puccinia, Albugo, Alternaria* and *Stemonitis* an important pathogenic fungus through herbarium specimen, and also know the mode of infection and different spore forms produced on host plants.
- To identify phytopathological symptoms of some common disease and also the symptoms of viral plant diseases.

CC IV: Archegoniate
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Introduction – Unifying features of archegoniates; Transition to land habit; Alternation of generations.

Unit 2: Bryophytes – General characteristics; Adaptations to land habit; Classification; Range of thallus organization.

Unit 3: Type Studies- Bryophytes – Classification (up to family), morphology, anatomy and reproduction of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and Funaria*; Reproduction and evolutionary trends in *Riccia, Marchantia, Anthoceros* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit 4: Pteridophytes – General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*).

Unit 5: Type Studies- Pteridophytes – Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy, and apospory, heterospory andseed habit, telome theory, stelar evolution; Ecological and economic importance.

Unit 6: Gymnosperms – General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included); Ecological and economic importance.

COURSE OUTCOMES

Students will learn:

- Features of archegoniate, alternation of generations.
- General characteristics; adaptation to land habit; classification of bryophytes, morphology, anatomy, and reproduction of different bryophytes, economic, and ecological importance of bryophytes.
- General characteristics, classification of pteriodphytes; early land plants, morphology, anatomy, and reproduction of different pteridophytes, economic and ecological importance of pteridophytes.
- General characteristics, classification of gymnosperms, their morphology, anatomy, and reproduction, economic, and ecological importance.

PRACTICAL

1. ***Riccia*** – Morphology of thallus.
2. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical sectionof thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata, spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. ***Pellia, Porella***- Permanent slides.
5. ***Sphagnum***- Morphology of plant, whole mount of leaf (permanent slide only).
6. ***Funaria***- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. ***Psilotum***- Study of specimen, transverse section of synangium (permanent slide).
8. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
9. ***Equisetum***- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. ***Pteris***- Morphology, transverse section of rachis, vertical section of sporophyll, wholemount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
11. ***Cycas***- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
12. ***Pinus***- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section &radial longitudinal sections stem (permanent slide).
13. ***Gnetum***- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)

14. Botanical excursion.

COURSE OUTCOMES

- Students will know about bryophytes, pteridophytes, and gymnosperms and also equipped with practical methods to study this group of plants.
- They can identify and differentiate according to their morphological and anatomical characters, and life cycle pattern.
- They will know about gametophytic and sporophytic generations, and their alternation in the life cycle in bryophytes, pteridophytes and gymnosperms.
- They will know the advancement of different morphological, anatomical and reproductive characters from bryophytes to gymnosperms and which they can correlate among the entire plant kingdom.
- From the botanical excursion, students will know the occurrence, and both seasonal and geographical distribution of these groups of plants.

Semester III

CC V: Morphology and Anatomy of Angiosperms
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Introduction and scope of Plant Morphology and Anatomy – Applications in systematics, forensics and pharmacognosy; Flower and Fruity Morphology

Unit 2: Structure and Development of Plant Body – Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development.

Unit 2: Tissues – Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Unit 3: Apical meristems – Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin oflateral root.

Unit 4: Vascular Cambium and Wood – Structure, function and seasonal activity of cambium; Secondary growth in root and stem. 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. Development and composition of periderm, rhytidome and lenticels.

Unit 5: Adaptive and Protective Systems – Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

COURSE OUTCOMES

Students will learn;

- Plant Morphology and Anatomy Introduction and Scope.
- Tissue system, Internal organization and development of plant body.
- Tissue classification; Cytodifferentiation of tracheary elements and sieve elements; study of pits, plasmodesmata, wall ingrowth, transfer cells, ergastic substances etc.
- Evolution of concept of organization of shoot apex, types of vascular bundles, structure of monocot and dicot stem; Origin development, arrangement and diversity in size and shape of leaves, structure of monocot and dicot leaves, Kranz anatomy. Organization of root apex.
- Structure, function and seasonal activity of cambium; Secondary growth in root and stem; Dendrochronology; Development and composition of periderm, rhytidome and lenticels.
- Epidermal tissue system, cuticle, epicuticle waxes, trichomes, stomatal classification, Anatomical adaptations of xerophytes and hydrophytes.

PRACTICAL

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.
2. Apical meristem of root, shoot and vascular cambium.
3. Distribution and types of parenchyma, collenchyma and sclerenchyma.

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

COURSE OUTCOMES

Students will be able:

- To know the methods of preparation of anatomical specimen and also to observe of anatomical details of different plant parts.
- To know the different types of plant tissues such as meristematic, permanent, epidermal, ground and vascular – their components, structure, distribution in plant body.
- To differentiate between primary and secondary growth, difference in tissues organisation in stem, leaf, and root of dicots and monocots.
- To understand the different adaptive anatomical features of plant tissue in relation to environment.
- To know the functions and importance of secretory tissues in plants.

CC VI: Economic Botany
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Origin of Cultivated Plants – Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

Unit 2: Cereals – Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

Unit 3: Legumes – Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Unit 4: Sources of sugars and starches – Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Unit 5: Spices – Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove, and black pepper.

Unit 6: Beverages – Tea, Coffee (morphology, processing & uses)

Unit 7: Sources of oils and fats – General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soyabean, mustard, and coconut (botanical name, family & uses). Essential oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit 8: Natural Rubber – Para-rubber: tapping, processing and uses.

Unit 9: Drug-yielding plants – Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis; Tobacco (morphology, processing, uses and health hazards.

Unit 10: Timber plants - general account with special reference to teak and pine.

Unit 11: Fibres – Classification based on the origin of fibres; cotton, coir and jute (morphology, extractions, and uses).

COURSE OUTCOMES

- Students will know the place of origin of important cultivated plants. They also know the basic types of cultivated plants like cereals, legumes, spices, oils and fats, fibre yielding species, their origin, family, morphology, processing, production and uses.
- They will get insight of basic concept of biotechnology, its importance.
- They will know the basic concepts of plant tissue culture techniques such as micropropagation, haploid production through androgenesis, and gynogenesis, and also the embryo and endosperm culture and their application to conserve and improve plant species.
- Students will understand the practical approach to study the plant biotechnology in which they will be familiarized with molecular tools and methods to know the techniques used in the avenue of plant biotechnology.

PRACTICAL

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

COURSE OUTCOMES

- Students will gain the knowledge regarding morphological, anatomical and biochemical aspects of some economically important plants such as Wheat, Gram, Soyabean, Black pepper, Clove, Tea, Cotton, and Groundnut.
- They will be familiarized with basic techniques and equipment used in tissue culture for conservation and propagation of important plants.
- They will gain the basic ideas about anther culture, somatic embryogenesis, endosperm and embryo culture and micropropagation through pictures and photographs.
- They will be acquainted to the basic techniques of molecular biology such as PCR, Blotting techniques, AGE and PAGE

CC VII: Genetics
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Mendelian genetics and its extension – Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

Unit 2: Extrachromosomal Inheritance – Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast;Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium.*

Unit 3: Linkage, crossing over and chromosome mapping – Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Unit 4: Variation in chromosome number and structure – Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

Unit 5: Gene mutations – Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method.Role of Transposons in mutation.DNA repair mechanisms.

Unit 6: Fine structure of gene – Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Unit 6. Population and Evolutionary Genetics – Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

COURSE OUTCOMES

Students will learn:

- The meaning of genetics, Mendelian genetics, its extension to modern genetics
- The inheritance mechanism other than chromosomal and its importance
- The variation due to natural and physical processes like mutation
- The concept of genes and population genetics relevant to species evolution

PRACTICAL

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
9. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red- green Colour blindness, Widow's peak, rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

COURSE OUTCOMES

Students will learn:

- The techniques of squash preparation of meiotic division, and also, they can verify the Mendel's laws practically.
- The chromosome mapping by point test cross data, pedigree analysis of dominant and recessive autosomal and sex-linked traits, meaning of gene interactions and related ratios.
- The basis of blood typing on the basis of ABO groups and Rh factor.
- Basic types of chromosomal abnormalities and their causes and consequences.
- Causes, impact and inheritance of different human genetic traits.

Skill Enhancement Course (SEC)
Medicinal Botany
(Credit: 2)

THEORY

Unit 1: History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definitionand Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used

in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

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

Unit 3: Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

COURSE OUTCOMES

Students will:

- Explore indigenous medicinal sciences including Ayurveda, Siddha, and Unani, and their concepts, origins, and treatment methods.
- Examine key concepts in Ayurveda such as panchamahabhutas, saptadhatu, tridosha, and Rasayana therapy.
- Investigate the principles and practices of Siddha and Unani medicinal systems, including the use of polyherbal formulations and treatments for specific conditions.
- Explore criteria for identifying and categorizing endangered species using Red List criteria. Learn propagation techniques for medicinal plants including nursery management, sowing, pricking, greenhouse production, and propagation methods such as cuttings, layering, grafting, and budding.
- Examine the use of folk medicines in different ethnic communities in India and their applications in treating specific diseases.
- Investigate the use of natural products derived from medicinal plants in the treatment of common ailments such as jaundice, cardiac diseases, infertility, diabetes, hypertension, and skin diseases.

Semester IV

CC VIII: Molecular Biology

(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Nucleic acids: Carriers of genetic information – Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment.

Unit 2. The Structures of DNA and RNA / Genetic Material – DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes.RNA Structure Organelle DNA -- mitochondria and chloroplast DNA.The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 2: The replication of DNA – Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi- conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

Unit 3: Central dogma and genetic code – Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features**)**

Unit 4: Transcription – Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

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

Unit 6: Translation – Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

COURSE OUTCOMES

Students will learn:

- The structure and functions of DNA and RNA as a carrier of genetic information
- The chemical structure of DNA and RNA, different model to explain their molecular configuration, DNA organisation in chromosome
- The DNA replication in prokaryotes and eukaryotes
- The central Dogma consisting of transcription, translation
- The transcription, processing and modification of RNA and translation in prokaryotes and eukaryotes

PRACTICAL

1. Preparation of LB medium and raising *E.Coli.*
2. Isolation of genomic DNA from *E.Coli.*

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

COURSE OUTCOMES

- Students will learn the process to grow bacteria in a specific medium, and DNA isolation from bacteria and also from plant species.
- They will learn to estimate DNA by spectrophotometric method and also know the principle behind it.
- They can understand the basics of some mechanisms and phenomena such as different types of DNA replication, DNA as genetic material, Spliceosome machinery and splicing of different groups of introns operated inside the cell at molecular level through photographs.

CC IX: Plant Ecology and Phytogeography
(Credit: Theory – 4, Practical – 2)

THEORY

Unit 1: Introduction – Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Unit 2: Soil – Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

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

Unit 4: Light, temperature, wind, and fire – Variations; adaptations of plants to their variation.

Unit 5: Biotic interactions – Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains, and webs; ecological pyramids; biomass, standing crop.

Unit 6: Population ecology – Characteristics, and dynamics, Ecological speciation.

Unit 7: Plant communities – Concept of ecological amplitude; Habitat and niche; characters: analytical and synthetic; Ecotone, and edge effect; Dynamic: succession – processes, types; climax concepts.

Unit 8: Ecosystems – Structure; Processes; Trophic organization; Food chains and food webs; Ecological pyramids.

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

Unit 10: Phytogeography – Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperature, and tundra); Phytogeographical division of India; Local vegetation.

COURSE OUTCOMES

Students will learn:

- The concepts of ecology and phytogeography, their importance
- The role of biotic components (producers, consumers, and decomposers), and abiotic components (water, light, temperature, soil) and energy flow in the ecosystem
- The population ecology, plant communities, ecosystem and parameters to study them
- The dynamic of ecosystem related to different biogeochemical cycles
- The localization and distribution of plant species, phytogeographical region and distribution of plants in India and world.

PRACTICAL

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

COURSE OUTCOMES

- Students will learn to use instruments to measure microclimatic variables.
- They will learn the importance of soil and water pH and their measurement and variations.
- Students will know the importance of biochemical parameters of soil and water sample (polluted and nonpolluted) and the experimental procedures to determine the same.
- They will know the morphological adaptive features of hydrophytes and xerophytes and also the biotic interaction of stem, and root parasites and epiphytes.
- They will be familiarized with the different ecological sites and know the methods of phytosociological analysis of herbaceous vegetation of nearby areas.

CC X: Plant Systematics
(Credits: Theory-4, Practical-2)

THEORY

Unit 1: Significance of Plant systematics – Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora;

Documentation: Flora, Monographs, Journals; Keys:Single access and Multi-access.

Unit 2: Taxonomic hierarchy – Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).

Unit 3: 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 4: Systems of classification – Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit 5: Biometrics, numerical taxonomy and cladistics – Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms – Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

COURSE OUTCOMES

Students will learn:

- The importance of identification, naming and classification of plants and the criteria/evidences for classification
- The taxonomic hierarchy related to classification, principles and rule of nomenclature and also the different systems of classification – artificial, natural, and phylogenetic
- The numerical taxonomy and phylogeny related to the evolution of angiosperms

PRACTICAL

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according tao Bentham & Hooker's system of classification):

Ranunculaceae	-	*Ranunculus, Delphinium*
Brassicaceae	-	*Brassica, Alyssum / Iberis*
Myrtaceae	-	*Eucalyptus, Callistemon*
Umbelliferae	-	*Coriandrum /Anethum / Foeniculum*
Asteraceae	-	*Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax*
Solanaceae	-	*Solanum /Physalis*
Lamiaceae	-	*Salvia/Ocimum/ Leucas*
Euphorbiaceae	-	*Jatropha / Croton / Acalypha*
Commelinaceac	-	*Commelina / Murdania / Cyanotis*
Poaceae	-	*Triticum/Hordeum/Avena*

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

COURSE OUTCOMES

- Students will learn the method of identifying plant species up to family level by observing morphology, and dissection of floral and vegetative parts.
- They will be acquainted to some important plant families.
- They will know the importance herbarium, preparation, mounting and preservation of plants for herbarium.

Semester V

Core courses

CC XI: Reproductive Biology of Angiosperms

(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Introduction – History (contributions of G.G. Amici, W. Hofmeister, E. Strasburger, S.G. Nwaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

Unit 2: Reproductive development – Introduction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

Unit 3: anther and pollen biology – Anther wall: structure and functions, microsporogenesis, callose deposition, and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall protein; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit 4: Ovule – Structure; Types; Special structures – endothelium, obturator, aril, caruncle and hypostase; Female gametophyte – megasporogenesis (monosporic, biosporic, and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

Unit 4: Pollination and fertilization – Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.

Unit 5: Self incompatibility – Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

Unit 6: Embryo, Endosperm and Seed – Structure and types; general pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia.* Seed structure, importance and dispersal mechanism.

Unit 7: Polyembryony and apomixis – Introduction; Classification; Causes and applications.

COURSE OUTCOMES

Students will learn:

- The detail structure of angiospermic reproductive structure, their development functions
- The mechanism of pollination and fertilisation, self-compatibility, their implication in production of hybrids and cybrids.
- The process of endosperm formation, seed and embryo development and unusual features during embryo development.

PRACTICAL

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

6. Intra-ovarian pollination; Test tube pollination through photographs.
7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
8. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

COURSE OUTCOMES

Students will:

- Know about the structure of anther, different stages of pollen mother cell, and dehiscence of anther.
- Know the structure of pollen grains, method of treatment to observe its important parts; modification of pollen grain, viability test, stages of pollen germination.
- Gain the idea about the structure and types of ovules, female gamethophyte, and its detail structure.
- Know about intra-ovarian and test tube pollination, the structure of endosperm, development of embryo, and seeds.

CC XII: Plant Physiology
(Credits: Theory – 4. Practical – 2)

THEORY

Unit 1: Plant-water relations - Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory.Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition – Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Nutrient Uptake – Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems,proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 4: Translocation in the phloem – Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators – Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of flowering – Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Unit 7: Phytochrome, cytochromes and phototropins – Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

COURSE OUTCOMES

Students will learn:

- The water potential; water absorption by roots; pathway of water movement; root pressure; guttation; Ascent of sap Theories, Transpiration.
- The macro and micronutrients; Mineral deficiency symptoms; essential elements; chelating agents, soil (as a nutrient

reservoir), faccilited diffusion; active absorption, Role of ATP, Passive absorption, electrochemical gradient, carrier systems, uniport, symport, antiport.

- The phloem as a site of sugar translocation, pressure flow model; Source Sink Relationship.
- The basic structure and Physiological roles of different plant growth regulators.
- The photoperiodism; Flowering stimulus, seed dormancy, discovery, chemical nature & mode of action of phytochromes, cytochrome and phototropins.

PRACTICAL

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

Demonstration experiments

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

COURSE OUTCOMES

- Students will be able to perform the physiological experiments to determine osmotic potential of cell sap, and water potential.
- They will understand phenomena of osmotic potential water potential, effect of light on seed germination, effect of different concentrations of IAA on coleoptile elongation, amylase activity in germinating grains.
- They also know the calculation percentage of stomata, stomatal index, and stomatal frequency and its occurrence pattern in mesophyte and xerophytes.

Discipline Specific Elective (DSE)
Plant Breeding
(Credit: Theory – 40, Practical – 2)

THEORY

Unit 1: Plant Breeding – Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievement and undesirable consequences of plant breeding.

Unit 2: Methods of crop improvement – Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinate, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3: Quantitative inheritance – Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.

Unit 4: Inbreeding depression and heterosis – History, genetic basis of inbreeding depression and heterosis; applications.

Unit 5: Crop improvement and breeding – Role of mutations; polyploidy; distant hybridization, and role of biotechnology in crop improvement.

COURSE OUTOCOMES

- Students will get insights of basics of plant breeding, its objectives and importance, limitations and drawback of plant breeding.
- They will know the basic methods of crop improvement adopted in plant breeding involving, selection, self-pollination, hybridisation, cross pollination, and vegetative propagation.
- They will get the idea about quantitative inheritance and its related aspects in desirable characters in plants.
- They will know the genetic basis of inbreeding depression and heterosis and its application and also the crop improvement by mutations, chromosome manipulations and biotechnological methods.

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

THEORY

Unit 1: Biostatistics – Definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.

Unit 2: Collection of data primary and secondary – Types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods.

Unit 3: Measures of central tendency – Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

Unit 4: Correlation – Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression

Unit 5: Statistical inference – Hypothesis - simple hypothesis - student 't' test - chi square test.

COURSE OUTCOMES

Students will:

- Learn the different methods of biostatistics, variable and related concepts and importance of statistics in life science.
- Know about primary and secondary data, data collection methods, their tabulation, presentation and sampling method.
- Know the concepts of measures of central tendency, correlation, their methods of study and implications in life science research.
- Learn the meaning of hypothesis testing; to make statistical inference, parametric and non-parametric tests.

PRACTICAL

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value

OUTCOMES

Students will learn:

- The concept of mean, standard deviation and standard error and their calculations practically.

- The calculation of correlation coefficient from the phenomena from plant science.
- The calculation of F value and its implications.

Semester VI

CC XIII: Plant Metabolism
(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Concept of metabolism – Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

Unit 2: Carbon assimilation – Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit 3: Carbohydrate metabolism – Synthesis and catabolism of sucrose and starch.

Unit 4: Carbon Oxidation – Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative photophosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 5: ATP-Synthesis – Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.

Unit 6: Lipid metabolism - Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.

Unit 7: Nitrogen metabolism - Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Unit 8: Mechanisms of signal transduction - Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

COURSE OUTCOMES

Students will learn:

- The concept of metabolism, their regulation and enzyme systems involve
- Carbon assimilation their components and pathways
- Carbon oxidation and related reactions and pathways
- ATP – synthesis, types and mechanism, and model to explain the process
- Lipid and nitrogen metabolism
- Signal transduction

PRACTICAL

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.

6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

COURSE OUTCOMES

Uon successful completion of the course, students will:

- Learn the techniques of chemical separation of photosynthetic pigments; the experimental set up and methodology of Hill's reaction.
- Understand the practical aspects of relationship between light intensity and photosynthetic rate, impact of carbon dioxide concentration on photosynthesis.
- Understand the respiration rates in various plant organs, basis of activity of nitrate reductase in germinating leaves and activity of lipases in germinating oilseeds and mobilization of lipids during this process.
- Learn the basis of fluorescence by isolated chlorophylls and absorption spectrum of photosynthetic pigments.

CC XIV: Plant Biotechnology

(Credits: Theory – 4, Practical – 2)

THEORY

Unit 1: Plant Tissue Culture - Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit 2: Recombinant DNA technology - Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 3: Gene Cloning - Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

Unit 4: 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 5: Applications of Biotechnology - Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

COURSE OUTCOMES

Students will learn:

- Historical perspective of plant tissue culture, Composition of media, organogenesis, somatic and zygotic embryogenesis, isolation culture and fusion of protoplast, application of tissue culture.
- Restriction Endonucleases (History, Types I-IV, biological role and application), Restriction Mapping (Linear and Circular), Cloning vectors.
- Recombinant DNA, PCR mediated gene cloning, transformation and selection of recombinant clones, construction

of genomic and cDNA libraries.

- Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Micro projectile bombardment.
- Application of biotechnology in Agriculture, medicine, industry and human health.

PRACTICAL

1. (a) Preparation of MS medium.

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

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

COURSE OUTCOMES

Upon completion of this course, students will:

- Understand the techniques involved in preparing MS medium and in vitro sterilization and inoculation.
- Gain knowledge of different tissue culture techniques through photographs.
- Develop skill in isolating protoplasts.
- Enhance problem-solving abilities by constructing restrictions maps of circular and linear DNA.
- Explore gene transfer methods, steps involved in genetic engineering for the production of transgenic plants through photographs.
- Acquire hands-on experience in isolating plasmid DNA.
- Deepen understanding of restriction digestion and gel electrophoresis techniques of plasmid DNA.

Discipline Specific Elective Course (DSE)
Analytical Techniques in Plant Science
(Credit: Theory – 4, Practical – 2)

THEORY

Unit 1: Imaging and related techniques – Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation – Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl^2$gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes – Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry – Principle and its application in biological research.

Unit 5: Chromatography – Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids – Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE.

Unit 7: Biostatistics – Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

COURSE OUTCOMES

Upon successful completion of this course, students will understand the detail principles for using microscopy, centrifugation, and other techniques to study biological systems and also develop the proficiency practical application of the same. They will understand the principles of spectrophotometry and chromatography, and how they are used to characterize proteins and nucleic acids; and be able to analyse and interpret biological data using statistical methods.

PRACTICAL

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

COURSE OUTCOMES

This practical course will prepare students for an in-depth exploration into foundational molecular biology techniques, as this course will guide you through a comprehensive array of protocols, including blotting techniques for DNA and protein analysis, PCR, ELISA, paper and thin-layer chromatography for biomolecules, centrifugation for chloroplast isolation, column chromatography for pigment separation, Lowry's method for protein quantification, PAGE for protein separation, AGE for DNA separation, and microscopy techniques for cellular visualization.

Discipline Specific Elective (DSE)
Natural Resource Management
(Credit: Theory – 4, Practical – 2)

THEORY

Unit 1: Natural resources – Definition and types.

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

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

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

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

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

Unit 7: Energy – Renewable and non-renewable sources of energy

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

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

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Understand the meaning, types and significance of natural resources; their sustainable utilization approach.
- Know the concept of significance and utilization of land, water and biological resources; different sources of water, and effective management of wetland.
- Get insight total availability of forest, and energy, their significance with special reference to India, different forest products, depletion and management.
- Understand the different contemporary resource management approaches, and also the national and international efforts in resource management and conservation.

PRACTICAL

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

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Estimate the amount of solid waste generated by a domestic system, differentiating between biodegradable and non-biodegradable components, and analyze its contribution to land degradation.
- Collect data on forest cover within a specific area using appropriate methods.
- Collect data on forest cover within a specific area using appropriate methods.
- Calculate and analyze the ecological footprint of individuals, and communities.
- Develop and apply ecological modeling techniques to understand and predict environmental changes.