Department of Botany
Course Outcome, Program Outcome and Program Specific Outcome, 2021-22

Course Outcome

Under CBCS
HONOURS

SEMESTER- I
CC1

THEORETICAL- PHYCOLOGY AND MICROBIOLOGY

PHYCOLOGY

CO1. General account: This course aims at acquainting students about the general organization of algal thallus as well as cytological details of the constituent cells. It also gives an idea regarding the different life cycle patterns prevalent among different groups of algae. Scope for developing awareness among the students about the remarkable contributions made by great phycologists has also been provisioned for.

CO2. Classification: Students are exposed to the different forms of classification proposed by renowned workers and are made aware about the basis behind them. Detailed information about the characteristic features of different major algal groups has also been provisioned for in this section. Students are also made aware regarding the ecological and economic implications of different groups of algae.

CO3. Life History: Scope for students to learn in details about the life-cycle pattern of selected member representatives of major algal groups has been provided for. Members have been carefully selected to give the readers a clear idea regarding the evolutionary pathway among algae.

MICROBIOLOGY

Virus:

CO1. Students are informed in details regarding the discovery, types, transmission and translocation of Plant viruses.

CO2. Provision for students to learn about physicochemical characteristics and Multiplication of well-known virus like TMV, T4 and Lambda phage has been made.

CO3. Students have the scope to learn about Viroids and Prions.

Bacteria:

CO1. Students get to learn about the discovery of Bacteria and its distinction from Archaea.

CO2. Students learn about the characteristics of some major groups of Bacteria.

CO3. They learn about the Bacterial growth curve and generation time in details.

CO4. Students get a detailed picture regarding the ultrastructure of a Bacterial cell and learn the basis of differentiation between Gram +ve & Gram – ve bacteria.

CO5. They have a thorough insight regarding Bacterial genome and plasmid, 2. Endospore - formation, structure and function, .Genetic Recombination (a) Transformation, Conjugation and Transduction.

PRACTICAL- PHYCOLOGY AND MICROBIOLOGY

ALGAE

CO1. Students get a first-hand experience of working-out major algal genera with reproductive structures accompanied by drawing under drawing prism with magnification.

CO2. Students get scope to study permanent slides and macroscopic specimens of algae belonging to different groups.

MICROBIOLOGY

CO1. Students have a first-hand experience of preparation of different bacterial media, slants and pouring of petri-plates.

CO2. They learn the techniques involved in sub-culturing of bacteria.

CO3. They have a hands-on training of staining and observing bacterial cell including Gram staining.

FIELD WORK

CO1. Scope has been provided for gaining first-hand experience in observation of plant diversity and collection and preservation of algae from field.

CC 2

THEORETICAL- MYCOLOGY AND PHYTO-PATHOLOGY

MYCOLOGY

CO1. General Account: Student gain general but detailed knowledge regarding the structural organization, sexuality, evolution of sex and life cycle patterns of fungi.

CO2. Classification: Students learn about a latest form of classification of fungi and knows about the salient characteristic features of major fungal groups.

CO3. Life history: Students get the opportunity to learn about the life-cycle patterns of some selected genera of fungi representing major groups.

CO4. Mycorrhiza: Students get to know about mycorrhiza, their types and roles in ecology and economy.

CO5. Lichen: Students learn about the types, reproduction and economic and ecological importance of lichens.

PHYTO-PATHOLOGY

CO1. Terms and Definitions: Students learn about the definitions and terminologies used in the study of plant diseases.

CO2. Host – Parasite Interaction: Students learn in details about the bio-chemical as well as mechanical procedures that play important role in host-parasite interaction during infection i.e. Pre-penetration, Penetration and Post-penetration.

CO3. They learn about the different methods used in Plant Disease Management.

CO4. Students gain detailed knowledge regarding symptoms , causal organism, disease cycle and control measures of carefully selected plant-diseases that have a deep-impact in the agricultural economy of our country.

PRACTICAL- MYCOLOGY AND PHYTO-PATHOLOGY

MYCOLOGY

CO1. Students have scope for gaining hands on experience on work out of selected fungal genera along with methodology for measurement of reproductive structures.

CO2. They will study some carefully selected genera from permanent slides.

CO3. Students will have access to fruit body of some fungi and lichens for gaining experience in morphological study.

PHYTO- PATHOLOGY

CO1. Student have provision for gaining hands-on training in preparation of fungal media, sterilization process, isolation of pathogen from diseased leaf, inoculation of fruit and subculturing.

CO2. They will gin training in procedures for identification of fungal diseases of plants that are of considerable economic importance.

FIELD WORK

CO1. Students will have the privilege of participating in field study involving study and collection of macro fungi.

Contact hours: 8hrs/week Practical: 8hrs/week

SEMESTER- II

CC 3

THEORETICAL- PLANT ANATOMY

ANATOMY

CO1. Cell wall: Students will gain detailed knowledge regarding ultrastructure of plant cell, tissue and organs, concept of Apoplast and Symplast, growth and thickening of cell wall etc.

CO2. They will have elaborate concept regarding stomata types, stellar types, stellar evolution, leaf-trace and leaf-gap.

CO3. Students will gain detailed idea about primary structure of leaf, stem and root of both monocot and dicot.

CO4. They will be acquainted with normal and anomalous secondary growth occurring in some carefully selected plant genus.

CO5. In-depth idea regarding mechanical tissues and the Principles governing their distribution in plants will be imparted to the students.

CO6. Students will be exposed to concepts regarding Developmental Anatomy involving organisation of shoot and root apex, plastochrone etc.

CO7. Ecological Anatomy: Students will gain in depth knowledge regarding the adaptive anatomical features of hydrophytes and xerophytes.

CO8. Students will be made aware about the scope and application of plant anatomy in the areas of systematics, forensics and pharmacognosy.

PRACTICAL- PLANT ANATOMY

PLANT ANATOMY

CO1. Students will have first-hand experience in microscopic studies on types of stomata, sclereids, raphides (Colocasia), cystolith (Ficus leaf) starch grains, aleurone grains, laticiferous ducts, oil glands.
CO2. They will study anatomical details of root, stem and leaf (both dicot and monocot) through permanent slides/ temporary stained mounts.
CO3. Students will have scope for in-depth study of anomalous secondary structure in stem and root of selected genera.
CO4. They will undertake study of adaptive anatomical features of hydrophytes and xerophytes.

CC 4

THEORETICAL- ARCHAEGONIATE

BRYOPHYTES

CO1. General Account : Students are exposed to detailed concept regarding general characteristics, adaptations and classification of Bryophytes.
CO2. Students will have in-depth idea about the life history of carefully selected genera.
CO3. Phylogeny: Students will gain detailed knowledge regarding unifying features of archaegoniates, transition to land habit, origin of Alternation of Generations, evolution of Sporophytes and origin of Bryophytes.
CO4. Importance: The learners will know about the in import role that bryophytes play in plant succession, pollution monitoring and learn about their economic and ecologic importance.

PTERIDOPHYTES

CO1. General Account: Students receive a detailed idea regarding colonisation and rise of early land plants, classification of vascular plants particularly Pteridophytes along with diagnostic characters and examples.
CO2. Life History: Students will get a detailed description of the life history of carefully selected bryophyte genera.
CO3. Learners will have in-depth concept about the Telome concept and its significance in the origin of different groups of Pteridophytes. They will also know about heterospory and origin of seed habit in Pteridophytes.
CO4. Students will learn about the economic importance of Pteridophytes as food, medicine and bio-fertilizer.

GYMNOSPERMS

CO1. Classification: Students will gain detailed idea regarding the classification of Gymnosperms along with diagnostic characters and examples.
CO2. Progymnosperms : They will learn in details about progymnosperms and their phylogenetic importance.
CO3. Life History : Students will have detailed knowledge about the life-cycle of carefully selected gymnosperm genera.
CO4. Students will learn the economic Importance of gymnosperms in details.

PRACTICAL- ARCHAEGONIATE

BRYOPHYTES

CO1. Students will have a first-hand experience regarding the morphological study of the plant body of selected bryophyte genera.
CO2. Students will have access to study reproductive structures of some bryophyte genera from permanent slides.

PTERIDOPHYTES

CO1. Students will have a first-hand experience regarding the morphological study of the plant body of selected pteridophyte genera.
CO2. They will have the opportunity to work out and learn in details about the reproductive structures of selected pteridophyte genera.
CO3. Students will have access to study reproductive structures of some pteridophyte genera from permanent slides.

GYMNOSPERMS

CO1. Students will have a first-hand experience regarding the morphological study of the plant body of selected gymnosperm genera.
CO2. Students will have access to study reproductive structures of some gymnosperm genera from permanent slides.

FIELD STUDY

Students will have the opportunity to familiarize themselves with the natural habitats of these groups of plants and develop concept about it.

Contact hours: 8hrs/week Practical: 8hrs/week

SEMESTER- III

CC 5

THEORETICAL- PALAEOBOTANY AND PALYNOLOGY

CO1. Students will gain detailed knowledge regarding Geological time scale with dominant plant groups through ages.
CO2. Plant Fossil: They will have elaborate concept regarding Body fossil (Micro- and Megafossils), Trace fossil, Chemical fossil, Index fossil; Different modes of preservation (Schopf, 1975); Conditions favouring fossilization; Nomenclature and Reconstruction; Principle of fossil dating and Importance of fossil study.
CO3. Fossil Pteridophytes: Students will gain detailed idea about Structural features, Geological distribution and Evolutionary significance of *Rhynia*, *Lepidodendron* (Reconstructed), *Calamites* (Reconstructed).
CO4. Fossil Gymnosperm: Students will gain detailed idea about structural features and Geological distribution of reconstructed genera: *Lyginopteris, Williamsonia, Cordaites*.
CO5. Indian Gondwana System: In-depth idea regarding Three fold division with major megafossil assemblages will be imparted to the students.
CO6. Palynology: Students will be exposed to concepts regarding Spore and Pollen; Pollen aperture types; NPC classification (Erdtman); Pollen wall-
Sporopollenin, Stratification and Ornamentation (sculpturing).

CO7. Applied Palynology: Students will gain in depth knowledge regarding the Basic concepts of Palaeopalynology, Aeropalynology, Forensic palynology and Melissopalynology.

PRACTICAL- PALAEOBOTANY AND PALYNOLOGY

CO1. Students will have experience in Morphological study: *Ptilophyllum* and *Glossopteris* leaf fossils.

CO2. They will study from permanent slides: T.S. of stem of *Rhynia*, *Lepidodendron, Calamites*, *Lyginopteris*, *Cordaites*.

CO3. Students will have scope for in-depth study of Pollen types (colpate, porate and colporate) from permanent slides. Slides will be prepared from specimens: Colpate (*Leonurus sibiricus/ Brassica* sp.), Porate (*Hibiscus rosa-sinensis*), Colporate (*Cassia sophera/ C. tora*).

CO4. Classroom Preparation: They will undertake prepation of Laboratory Note Book of each section must be signed by the respective teacher with date during practical classes.

CC 6

THEORETICAL- REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Morphology of angiosperms

CO1. Students will learn about Inflorescence types with examples.

CO2. Students will have in-depth idea about Flower, induction of flowering, flower development- genetic and molecular aspects.

CO3. They will know about Fruits and seeds - types with examples.

Embryology

CO1. Pre-fertilisation changes: Students will have an indepth understanding about Microsporogenesis and Microgametogenesis, Megasporogenesis and Megagametogenesis (monosporic, bisporic and tetrasporic).

Fertilization

CO1. Students receive a detailed idea regarding Pollen germination, Pollen tube- growth, entry into ovule and discharge, Double fertilization.

Post Fertilization Changes

CO1. Classification: Students will gain detailed idea regarding Embryogenesis in Capsella, Development of Endosperm (3 types).

Apomixis and Polyembryony

CO1. Students receive a detailed idea regarding Apomixis- Apospory and Apogamy, Polyembryony- different types.

PRACTICAL- ARCHAEGONIATE REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

CO1. Students will have a first-hand experience regarding the Inflorescence types- study from fresh/ preserved specimens.

CO2. Students will have access to study Flowers- study of different types from fresh/ preserved specimens.

CO3. Students will have access to study Fruits- study from different types from fresh/preserved specimens.
CO4. Students will have a first-hand experience regarding Study of ovules (permanent slides/ specimens/photographs)- types (anatropous,
orthotropous, amphitropous and campylotropous).

FIELD STUDY

CO1. Students will have the opportunity to familiarize themselves with the reproductive parts and modes of reproduction in different plants and develop concept about it.
CO2. They will undertake a project supported along with photographs taken during field study to be submitted giving
comprehensive idea about different types of inflorescence, flowers and fruits.

Contact hours: 8hrs/week Practical: 8hrs/week

CC7

THEORETICAL- PLANT SYSTEMATICS

Taxonomy of Angiosperms

CO1. Introduction: Students have a indepth concept about components of Systematic, Nomenclature, Identification, Classification; Taxonomy and its
phases - Pioneer, Consolidation, Biosystematic and Encyclopaedic; alpha- and omega- taxonomy.
CO2. Nomenclature: They gain knowledge regarding Type method, Publication, Rank of taxa, Rules of priority, Retention and rejection of names, Author Citation, Effective and valid publication, Elementary knowledge of ICN- Principles.
CO3. Systems of classification: Students have a broad outline of Bentham & Hooker (1862-1883), Cronquist (1988), Takhatajan (1991) - system of
classification with merits and demerits. Brief reference of angiosperm phylogeny group (APG III) classification; Systematics in Practice: Herbaria and Botanical Gardens – their role in teaching and research;
important Herbaria and Botanical Gardens of India and world (3 each); Dichotomous keys – indented and bracketed.
CO4. Phenetics and Cladistics: Students gain brief idea on Phenetics, Numerical taxonomy- methods and significance; Cladistics- construction
of dendrogram and primary analysis; Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy.
CO5. Data sources in Taxonomy: Students learn about supportive evidences from Phytochemistry, Cytology, Palynology and Molecular
biology data (Protein and Nucleic acid homology).
CO6. Students gain detailed concept regarding diagnostic features, Systematic position (Bentham & Hooker and Cronquist), Economically
important plants (parts used and uses) of the following families:

Monocotyledons: Alismataceae, Gramineae (Poaceae), Cyperaceae, Palmae (Arecaceae), Liliaceae, Musaceae, Zingiberaceae, Cannaceae, Orchidaceae.
Dicotyledons: Nymphaeaceae, Magnoliaceae, Leguminosae (subfamilies), Polygonaceae, Euphorbiaceae, Malvaceae, Umbelliferae (Apiaceae), Labiatae (Lamiaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Compositae (Asteraceae).

PRACTICAL- PLANT SYSTEMATICS

Angiosperms

CO1. Students gain hands on training in plant work out, description, preparation of floral formula and floral diagram, identification up to genus
with the help of suitable literature of wild plants and systematic position according to Bentham & Hooker's system of classification from the following families: Malvaceae, Fabaceae (Papilionaceae),
Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.
CO2. The gain skill in Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus (list to be provided).

Field Work

CO1. Students will have the opportunity to participate in at least three excursions including one excursion to Acharya Jagadish Chandra Bose Indian Botanic Garden (Shibpur, Howrah) and Central National Herbarium (CNH).

FIELD RECORDS

CO1. Students will learn the procedures of writing Field Note Book with field notes on the plants of the area of excursion and workout on Angiosperms; Spot Identification; keeping of Lab records and Field Records (Field note book, herbarium specimens, voucher specimen book etc.).

SEC-A: SKILL ENHANCEMENT COURSE

THEORETICAL- APPLIED PHYCOLOGY, MYCOLOGY AND MICROBIOLOGY

Applied Phycology

CO1. Students will learn about Algae as food and source of phycocolloid (Agar-agar, Algin, Carrageenan), 2. Diatomite, 3. Algal toxin, 4. Algal Biotechnology – potential of microalgae for SCP, β-carotene, Biodiesel, bioplastics from algae.

Applied Mycology

CO1. They will learn the use of Fungi as food, 2. Cheese and Ethanol- Industrial production (brief outline), 3. Fungal sources and uses of Enzyme (Cellulase), Amino acid (Tryptophan), Vitamin (Riboflavin), Antibiotic (Griseofulvin), Pharmaceuticals (Cyclosporin-A). 4. Aflatoxin.

Applied Microbiology

CO1. Students will gain knowledge regarding Industrial Production of Vinegar and Streptomycin (brief outline).
CO2. They will learn the Microbial sources and uses of Enzyme (Amylase, Protease), Amino acid (Glutamic acid, Lysine), Polysaccharides (Dextran).

CO3. They will be acquainted about the use of microbes as Biofertilizer and Biopesticides, 3.4. Use of microbes in mineral processing.

THEORETICAL- BIOFERTILIZERS

CO1. Students will learn the general account about the microbes used as biofertilizers- *Rhizobium*- isolation, identification, mass multiplication, carrier based inoculants, actinorrhizal symbiosis.

CO2. They will learn in details about *Azospirillum*: isolation and mass multiplication- carrier based inoculants, associative effect of different microorganisms.

CO3. They will learn in details about *Azotobacter*: classification, characteristics- crop response to *Azotobacter* inoculants, maintenance and mass multiplication.

CO4. They will learn in details about Cyanobacteria (Blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation. Factors affecting growth, blue green algae and *Azolla* in rice cultivation.

CO5. Students will learn in details about Mycorrhizal association, types of mycorrhizal association, phosphorus nutrition, growth and yield- colonisation of VAM – isolation and inoculum production of VAM and its influence on growth and yield of crop plants.

CO6. Organic farming- green manuring and organic fertilizers, recycling of biodegradable municipal, agricultural and industrial wastes- biocompost making methods, types and methods of vermicomposting- field application.

SEMESTER IV

CC-8

THEORETICAL-PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION

Plant Geography

CO1. Phytogeographical regions: Students get to learn about the Phytogeographical regions of India (Chatterjee 1960); Dominant flora of Eastern Himalaya, Western Himalaya and Sunderban.

CO2. Endemism: They gain detailed concept regarding Endemic types and Factors; Age & Area hypothesis and Epibiotic theory; Endemism in Indian flora.

Ecology

CO1. Preliminary idea: Students will have preliminary idea about Habitat and Niche, Ecotone and edge–effect, Microclimate, Ecads, ecotype and ecoclines, Carrying capacity.

CO2. Community ecology: They will develop idea about Community- Characteristics and diversity, Ecological succession –Primary and secondary, Seral stages (with reference to Hydrosere), autogenic and allogenic succession.

CO3. They will learn about Plant indicators (metallophytes); Phytoremediation.

CO4. Conservation of Biodiversity: Students will develop elaborate concepts regarding Level of Biodiversity: genetic, species & ecosystem diversity, Biodiversity hot spots- criteria, Indian hotspots, In- situ and ex-situ conservation, Seed-banks, Cryopreservation.

Evolution

CO1. Introduction: Students will learn about the Theories of evolution: Natural selection, Group selection, Neutral theory of molecular evolution, Phyletic gradualism, Punctuated equilibrium and Stasis

CO2. Brief idea on: They will have elaborate idea about stabilizing, directional, disruptive and sexual selection; Speciation: Sympatric and allopatric speciation; Coevolution, Adaptive radiation, Reproductive isolation.

CO3. Students will come to know about simplified phylogeny of bacteria, algae, fungi, bryophyte, pteridophyte and gymnosperm, Phylogenetic tree.

PRACTICAL- PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION

Plant Geography

CO1. Students will have the scope of gaining first-hand knowledge about vegetation study through Field visit- at least one long excursion at different phytogeographical region of India.

CO2. They will undertake study of local flora and submission of a project report highlighting phytogeographical characteristics of the region.

Ecology

CO1. Students will learn the procedure of study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Frequency, density and abundance of components (to be done during excursion/ field visit).

CO2. Students will have the scope to study comparative anatomical studies of leaves form polluted and less polluted areas.

CO3. They will learn about measurement of dissolved O2 by azide modification of Winkler's method.

CO4. They will learn to compare free CO2 from different sources.

CO5. Students will maintain Field Records (Field note book of phytogeographical study and ecological study)

CC- 9

THEORETICAL- ECONOMIC BOTANY

CO1. Origin of cultivated crops: Students will learn the concepts of centre 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.

CO2. Cereals: They will know the origin, morphology, processing and uses of Rice and wheat.

CO3. Legumes: They will come to know the origin, morphology and uses of gram and mung bean. Importance to man and environment.

CO4. Sugar and starches: Students will gain knowledge regarding the morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato- morphology, propagation and uses.

CO5. Spices: They will be able to list important spices, their family and part used.

CO6. Beverages: Students will learn about the morphology, processing and uses of Tea.

CO7. Oil and fats: Students will learn about the general description, classification, extraction, their uses and health implications of mustard, soybean, coconut (Botanical name, family and uses). Essential oils- general account, extraction methods, comparison with fatty oils and their uses.
CO8. Drug-yielding plants: They will have in-depth knowledge regarding the therapeutic and habit forming drugs with special reference to Cinchona, Digitalis, Papavar, Cannabis and Tobacco (morphology, processing, uses and health hazards).
CO9. Timber: They will have a general account with special reference to Sal and Teak.
CO10. Fibers: Students will learn the morphology, extraction and uses Cotton and Jute.

PRACTICAL- ECONOMIC BOTANY

Economic Botany

CO1. Cereals: Students will have general idea about Wheat (habit sketch, L.S./T.S. of grain, starch grains, micro-chemical tests); rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests)
CO2. Legume: They will have detailed knowledge about Soybean, ground nut (habit, fruit, seed structure, micro-chemical tests)
CO3. Source of sugars and starches: Students will have general idea about Sugarcane (habit sketch; cane juice- micro-chemical tests); potato (habit sketch, tuber morphology, T.S. of tuber to show localization of starch grains, W.M. of starch grains, micro-chemical tests.
CO4. Students will have detailed idea about Tea- tea leaves, tests for tannin
CO5. Students will have detailed idea about Mustard- plant specimen, seeds, tests for fat in crushed seeds
CO6. They will be able to make habit sketch of Digitalis, Papaver and Cannabis.
CO7. They will be able to make Sal, Teak- section of young stem.
CO8. They will be able to make Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fibre following maceration technique.

CC-10

THEORETICAL- GENETICS

CO1. Introduction: Students will develop concept about Mendelian genetics and its extension.
CO2. They will learn in details about Linkage, Crossing over and Gene Mapping: Complete and incomplete linkage (example), linked gene does not assort independently (example), linkage group, Crossing over, crossing over produces recombination (example), detection of crossing over (McClintock's experiment), and Molecular mechanism of crossing over (Holliday model), 2.4. Gene mapping with three point test cross, detection of middle gene in three point test cross, calculation of recombination frequencies, 2.5. Co-efficient of coincidence.
CO3. They will have the opportunity of a field visit desirable to give an idea about cultivation of any crop (viz. rice, jute, mustard, tea, potato)

CO4. They will keep field record of the visit, properly authenticated by escorting teacher. interference, mapping function, Problems on gene mapping, Molecular mapping – ISH, FISH (brief idea).
CO5. Students will learn in details regarding Epistasis and Polygenic inheritance in plants.
CO6. Aneuploidy and Polyploidy: They will know about the types, examples, meiotic behaviour and importance of: Aneuploidy, Polyploidy, Speciation and evolution through polyploidy.
CO7. Chromosomal aberration: They will know about the types and meiotic behaviour of: Deletion, Duplication, Translocation, and Inversion.
CO8. Mutation : Students will have in-depth concept regarding Point mutation-Transition, Transversion and Frame shift mutation, Molecular mechanisms (tautomerisation, alkylation, deamination, base analogue incorporation, dimerisation), DNA repair (brief idea).
CO9. Students will learn in details about the structural organisation of Gene: One Gene–one polypeptide concept, Split gene, Overlapping gene, Repetitive DNA tandem and interspersed, Transposon (Ac-Ds system), Homoeotic gene in plants (ABCE Quartet model of flowering).

PRACTICAL- GENETICS

Genetics

CO1. Introduction to chromosome preparation: Students will have hands on training in pre-treatment, Fixation, Staining, Squash and Smear preparation, Preparation of permanent slides.
CO2. They will learn determination of mitotic index and frequency of different mitotic stages in pre-fixed root tips of Allium cepa.
CO3. Study of mitotic chromosome: They will learn the skills of metaphase chromosome preparation, free hand drawing under high power objective, drawing with drawing prism under oil immersion lens, determination of 2n number, and comment on chromosome morphology of the following specimens from root tips: *Allium cepa, Aloe vera, Lens esculenta.*
CO4. They will study chromosomal aberrations developed due to exposure to any two pollutants/ pesticides etc.
CO5. Study of meiotic chromosome: The will undertake smear preparation of meiotic cells, identification of different stages and free hand drawing of the following specimens from flower buds: *Allium cepa* and *Setcreasea* sp.
CO6. Identification from permanent slides : Students will gain skill in Meiosis – (i) normal stages (ii) abnormal stages – laggard, anaphase bridge, ring chromosome (*Rhoeo discolor*); Mitosis – (i) normal stages, (ii) abnormal stages early separation, late separation, multipolarity, sticky bridge, laggard, fragmentation, (ii) pollen
mitosis.

SEC-B- SKILL ENHANCEMENT COURSE
THEORETICAL-PLANT BREEDING

CO1. Students will have an idea about introduction and objectives, breeding systems- modes of reproduction incrop plants, important achievements and undesirable consequence of plant breeding.

CO2. They will lkearn in details about methods of crop improvement: Introduction- centres of origin and domestication of crop plants, plant genetics resources; acclimatization, selection methods- for self-pollination, cross pollinated and vegetatively propagated plants, hybridization- for self, cross and vegetatively propagated plants, procedure, advantages and limitations.

CO3. They will learn the techniques of maintenance of germplasm, mass selections and Pure line selection, Back crossmethod.

CO4. Students will be exposed to the idea of Heterosis and hybrid seed production, Male sterility and its use in plant breeding.

CO5. They will learn about Inbreeding and inbreeding depression, effect of outcrossing- a very brief idea.

CO6. Students will learn in details about Molecular Breeding (use of DNA markers in plant breeding).

CO7. They will know about the role of mutations, polyploidy, distant hybridization and role of biotechnology in cropimprovements.

THEORETICAL-MUSHROOM CULTURE TECHNOLOGY

CO1. Students will have an introduction, nutritional and medicinal value of edible mushrooms; poisonous mushrooms, types of edible mushrooms available in India- *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*.

CO2. Students will gain indepth knowledge about the cultivation technology: infrastructure: substrates (locally available), polythene bags, vessels, inoculation hook, inoculation loop, low cost stoves, sieves, culture racks, mushroom unit (thatched house), water sprayer, tray, small polythene bag. Pure culture: medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation- paddy straw, sugarcane trash, maize straw, banana leaves,. Factors affecting the mushroom bed preparation- low-cost technology, composting technology in mushroom production.

CO3. They will know about storage and nutrition: short term storage (Refrigeration- upto 24 hours), long term storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition- proteins- amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.

CO4. Students will gain knowledge about food preparation: type of foods prepared from mushroom. Research centres- National leveland regional level. Cost benefit ratio- marketing in India and abroad. Export value.

SEMESTER V

CC-11

THEORETICAL- CELL AND MOLECULAR BIOLOGY

CO1. Students will know in details about the origin and evolution of cells, nucleic acid (from PNA to DNA). They will develop concept of RNA world, Ribozymes, First cell, origin of eukaryotic cell (endosymbiotic theory), small RNA- riboswitch, RNA interference, si RNA, mi RNA and organellar DNA (cp- and mt- DNA).
CO2. They will learn in details about nucleus and chromosome like nuclear envelope, nuclear lamina and nuclear pore complex, nucleolus-ultrastructure and ribosome biogenesis, chromatin ultrastructure and DNA packaging in eukaryotic chromosome, centromere: types, structure and function.
CO3. They will develop concept about cell cycle and its regulation like kinetochore and spindle apparatus-structural organization and functions, Microtubules- structure, organization and function, mechanism of cell cycle control in Yeast (checkpoints and role of MPF), Apoptosis etc.
MOLECULAR BIOLOGY
CO4. Students will gain in depth knowledge about DNA Replication, Transcription and Translation (Prokaryotes & Eukaryotes), Central Dogma, semiconservative DNA replication – mechanism, enzymes involved in DNA replication- DNA polymerase, DNA gyrase, Helicase, Ligase, primase and other accessory proteins, eukaryotic replication with special reference to replication licensing factor, assembly of new nucleosome, replication at the end chromosome telomere, telomerase concept, fidelity of DNA replication- prokaryote: nucleotide selection, proof reading, mismatch repair; eukaryote: through selection of error prone DNA polymerase, transcription, RNA processing, Aminoacylation of tRNA and Translation.
CO5. Students will develop an understanding regarding Gene Regulation: concept of Lac-operon, positive and negative control etc.
CO6. They will gain knowledge about Genetic Code, properties-evidences & exceptions, decipherence of codon (Binding technique).
CO7. They will know the steps involved in Recombinant DNA Technology, Restriction endonuclease, - types and roles, Vector (plasmid pBR 322), Marker gene, Steps of cloning technique, PCR and its application, Genomic DNA and cDNA library.
CO8. Students will know about development and causes of Cancer (in general and brief), tumor suppressor gene and oncogene.

PRACTICAL- CELL BIOLOGY
CO1. Students will learn to study plant cell structure with the help of epidermal peal mount of Onion/Rhoeo/Crinum.
CO2. They will learn the skill regarding measurement of cell size by the technique of micrometry.
CO3. They will muster the skill involving counting cells per unit volume with the help of haemocytometer (Yeast/pollengrains).
CO4. They will learn Cytochemical staining of DNA- Pyronine-methyl green staining.
CO5. They will learn the procedure behind estimation of DNA content through DPA staining.
CO6. They will learn the procedure behind estimation of RNA through orcinol method.

CO7. They will learn the procedure behind study of nucleolus through hematoxylin/ orcin staining and determination of nucleolar frequency.
CO8. They will gain proficiency in preparation of models/ charts: rolling circle, theta replication, semi-discontinuous replication, prokaryotic RNA polymerase and eukaryotic RNA polymerase II, assembly of spliceosome mechinary, splicing mechanism in group I and group II introns, ribozyme and alternative splicing.

SEMESTER V
CC-12
THEORETICAL- BIOCHEMISTRY
CO1. Students will develop Biochemical Foundations: Covalent and non-covalent bonds; hydrogen bond; Van der Waal's forces; Structure and properties of water; pH and buffer (inorganic and organic); Handerson-Hasselbalch equation; Isoelectric point.
CO2. Students will develop concept about Molecules of life: Nucleic Acids – structure of nucleosides and nucleotides ; oligo- and poly nucleotides , B & Z form of DNA, RNA- different forms; nucleotide derivatives (ATP, NADP), Proteins – structure and classification of amino acids; primary, secondary, tertiary and quaternary structure of proteins; Carbohydrates - structure of mono-, di- and polysaccharide; stereoisomers, enantiomers and epimers; Lipids - structure of simple lipid and compound lipid (phospholipids and glycolipids), fatty acids- saturated and unsaturated.
CO3. They will develop a strong foundation about Energy flow and enzymology: Bioenergetics- Thermodynamic principles; free energy; energy rich bonds- phosphoryl group transfer and ATP; redox potentials and Biological redox reactions, Enzymes – classification and nomenclature (IUBMB); Co-factors and co-enzymes; isozymes, Mechanism of enzyme action; enzyme inhibition; Enzyme kinetics (Michaelis- Menten equation) and simple problems.
CO4. They will develop knowledge about Cell membrane: Membrane chemistry, Membrane transport (uniport, symport, antiport), mechanism of ion uptake.
CO5. Students will gain concept on **Phosphorylation:** ATP Synthesis- Chemiosmotic model, Oxidative and Photophosphorylation-Mechanism and differences.

PRACTICAL- BIOCHEMISTRY
CO1. Students will have workout on different topics of Plant Biochemistry (Quantitative & Qualitative)
Qualitative:

1. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.
2. Detection of carbohydrate and protein from plant samples.
3. Detection of the nature of carbohydrate – glucose, fructose , sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S from plant ash sample.

Quantitative:

1. Preparation of solutions and buffers.
2. Estimation of amino-nitrogen by formol titration method (glycine) .
3. Estimation of glucose by Benedicts quantitative reagent.
4. Estimation of titratable acidity from lemon.
5. Estimation of catalase activity in plant samples and effect of substrate, enzyme concentration andpH on enzyme activity.
6. Estimation of urease activity in plant samples.
7. Colorimetric estimation of protein by Folin phenol reagent.

DSE A1- DISCIPLINE SPECIFIC ELECTIVE COURSES
THEORETICAL- BIOSTATISTICS

CO1. Biostatistics: Definition, statistical methods, basic principles, variables- measurements, functions, limitations and uses of statistics. Biometry: Data, Sample, Population, Random sampling, Frequency distribution- definitiononly. Central tendency– Arithmetic Mean, Mode and Median; Measurement of dispersion– Coefficient of variation, Standard Deviation, Standard error of Mean, Test of significance: chi- square test for goodness of fit, Probability- multiplicative and additive rules of probability: application and importance, Measurement of gene frequency: Hardy-Weinberg equilibrium- conditions applied for its implications (simple problems to calculate genotypic and allelic frequencies).

PRACTICAL- BIOSTATISTICS

CO1. Students will attain proficiency in the following statistical analysis:

1. Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (using seedling population / leaflet size).
2. Calculation of correlation coefficient values and finding out the probability.
3. Determination of goodness of fit in Mendellian and modified mono-and dihybrid ratios (3:1, 1:1, 9:3:3:1, 1:1:1:1, 9:7, 13:3, 15:1) by Chi-square analysis and comment on the nature of inheritance.
4. Calculation of 'F' value and finding out the probability value for the F value
5. Basic idea of computer programme for statistical analysis of correlation coefficient,'t' test, standard error, standard deviation.

DSE A2-
THEORETICAL- INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

CO1. Students will learn about the scope of microbes in industry and environment.
CO2. They will learn in details about Bioreactors/ Fermenters and fermentation process: solid-state and liquid-state (stationary and submerged) fermentations; batch and continuous fermentations. Components of a typical bioreactors, types of bioreactors- laboratory, pilot scale and production fermenters. Constantly stirred fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air- lift Fermenter.
CO3. They will know in details about microbial production of industrial products: microorganisms involved, media, fermentation conditions, down stream processing and uses; filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, liophilisation, spray drying, hands on microbial fermentations for the production and estimation of enzymes amylase or lipase activity, organic acids (citric or glutamic acid), alcohol (ethanol) and antibiotic (Penicillin).
CO4. Students will know about microbial enzymes of industrial interest and enzyme immobilization: microorganisms for industrial applications. Methods of immobilization, advantages and applications of immobilization, large scale application of immobilized enzymes (glucose isomerase and penicillin acylase).
CO5. Students will learn about microbes and quality of environment: distribution of microbes in air, isolation of microorganisms from soil, air and water.
CO6. Students will know about microbial flora of water: water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD of water samples. Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.
CO7. They will gain knowledge about microbes in agriculture and remediation of contaminated soils: biological fixation, mycorrhizae, bioremediation of contaminated soils, isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

PRACTICAL- INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

CO1. Students will develop hands on skill on the following procedures:

1. Principals and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Preparation of slant, stab and pouring petriplate. .
4. A visit to any educational institute/ industry to see an industrial fermenter, and other down- stream processing operations.

DSE B5
THEORETICAL- PLANT BIOTECHNOLOGY
CO1. Students will have indepth idea about plant tissue culture –Introduction: Basic concept and milestones, Cellular totipotency, Tissue culture media, Aseptic manipulation, Cyto-differentiation and dedifferentiation.
CO2. They will have detailed idea about callus culture: Callus induction, maintenance and

application, Suspension culture- introductory idea.
CO3. Students will know about plant regeneration: Organogenesis (direct and indirect), Somatic embryogenesis, Significance of organogenesis and somatic embryogenesis, Artificial seed.
CO4. They will know about Haploid Culture: Anther and Pollen culture methods, Applications.
CO5. They will also learn about Protoplast Culture: Protoplast isolation and culture, Protoplast fusion (somatic hybridization), Significance.
CO6. Students will gain concept about Plant Genetic Engineering: Brief concept of different gene transfer methods, special emphasis on *Agrobacterium* mediated gene transfer, Role of Reporter gene, Achievements in crop biotechnology, environment and industry (suitable example)- pest resistant plants (BT cotton), herbicide resistance, disease and stress tolerance, transgenic crop with improved quality (flavr tomato, golden rice), role of transgenic in population degradation (super-bug), leaching of minerals, production of industrial enzymes, oil, edible vaccine.

PRACTICAL- PLANT BIOTECHNOLOGY

CO1. Students will have a hands on experience on:

1. Familiarization of basic equipments in plant tissue culture
2. Study through photographs/ charts/ models of anther culture, somatic embyogenesis, endosperm and embryo culture, micropropagation.
3. Preparation of basal media. Sterilization techniques.
4. Demonstration of any tissue culture technique during visit in a plant tissue culture lab.

DSE B6
THEORETICAL- HORTICULTURAL PRACTICES AND POST- HARVEST TECHNOLOGY
CO1. Students will know the following things about Horticulture –scope, importance and branches. Role in rural economy and employment generation; importance in food and nutritional security; urban horticulture and ecoturism.
CO2. They will gain knowledge about ornamental plants: types, classifications (annuals, perennials, climbers and trees), identification and salient features of some ornamental plants (rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulants). Ornamental flowering trees (Indian laburnum, gulmohor, jacaranda, Lagerostoemia, fishtail and Erica palms, simul, coral tree).
CO3. Students will know about fruit and vegetable crops: production, origin and distribution; description of plants and their economic products; management and marketing of vegetables and fruit crops; identification of some fruits and some vegetables varieties (citrus, banana, mango, chillis and cucurbits).
CO4. Students will attain knowledge about horticultural techniques: application manures, fertilizers, nutrients and PGRs; weed controls, biofertilizers, biopesticides, irrigation methods.

Hydroponics, propagation methods; vegetative (grafting, cutting, layering, budding), sexual (seed production), scope and limitations.
CO5. They will learn about landscaping and garden designing: planning and lay out (parks and gardens).
CO6. They will know in details about Floriculture: cut flowers, bonsai, commerce (market demand and supply), importance of flower shows and exhibitions.
CO7. Students will have a vivid idea about Post harvest technology: Importance of post harvest technology in horticultural crops, evaluation of quality, traits; harvesting and handling of fruits, vegetables, cut flower; principles, methods of preservation and processing, methods of minimizing losses during storage and transportation; food irradiation- advantages and disadvantages; food safety.
CO8. They will learn about disease control and management: field and post harvest diseases, identification of deficiency symptoms, remedial measures and nutritional management practices; crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); quarantine practices; identification of common diseases and pest of ornamental fruits and vegetable crops.
CO9. They will know about horticultural crops- conservation and management: documentation and conservation of germplasm. Role of micropropagation and tissue culture techniques; varieties and cultivars of various horticultural crops; IPR issues, national international and professional societies and sources of information on horticulture.

PRACTICAL- HORTICULTURAL PRACTICES AND POST- HARVEST TECHNOLOGY

CO1. Students will undertake a field visits to gardens, standing crop sites, nurseries, vegetable gardens, horticultural fields at IARI/AHSI or other suitable locations and if possible to cold storage.

SEMESTER VI

CC-13
THEORETICAL- PLANT PHYSIOLOGY Plant-water relations:

CO1. Students will develop concept about water potential, components of water potential in plant system, Soil-plant- Atmosphere continuum concept, Cavitation in xylem and embolism, Stomatal physiology- mechanism of opening and closing, Role of carbon di-oxide, potassium ion, abscisic acid and blue light in stomatal movement, Antitranspirants.

CO2. They will know in details about 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.

CO3. Students will learn about Organic Translocation: Phloem sap, P-protein, Phloem loading and unloading, Mass-flow (pressure flow)hypothesis and its critical evaluation.

CO4. Students will know in details about Plant Growth Regulators: Physiological roles of Auxin, Gibberellin, Cytokinin, Abscisic acid, Ethylene, Chemical nature –IAA, GA3, Kinetin, Biosynthesis and bioassay of IAA, Mode of action of IAA, Brassinosteroids and Polyamines as PGRs (brief idea).

CO5. Students will develop concept of photomorphogenesis, Photoperiodism and plant types, Perception of photoperiodic stimulus, Critical day length, concept of light monitoring, Phytochrome, cryptochrome and phototropins- chemical nature and role in photomorphogenesis, Role of GA in flowering, Vernalisation – role of low temperature in flowering, Concept of biological clock and biorhythm.

CO6. They will know about seed dormancy**:** types, Causes and Methods of breaking seed dormancy, Biochemistry ofseed germination.

CO7. They will develop concept about physiology of Senescence and Ageing.

PRACTICAL- PLANT PHYSIOLOGY

CO1. Students will have a hands on experience on

1. Determination of loss of water per stoma per hour.

2. Relationship between transpiration and evaporation.

3.Measurement of osmotic pressure of storage tissue by weighing method.

4. Measurement of osmotic pressure of *Rhoeo* leaf by plasmolytic method.

5. Effect of temperature on absorption of water by storage tissue and determination of Q_{10}.

6. Rate of imbibition of water by starchy, proteinaceous and fatty seeds and effect of seed coat.

7. To study the phenomenon of seed germination (effect of light).

8. To study the induction of amylase activity in germinating grains.

9. To study the effect of different concentrations of IAA on *Avena* coleopotile elongation (IAA bioassay)

CC-14

THEORETICAL-PLANT METABOLISM

CO1. Students will develop concept of metabolism: Introduction, Anabolic and catabolic metabolic pathways, regulation ofmetabolism, role of regulatory enzymes (allosteric, covalent modulation and isozymes)

CO2. They will learn in details about Photosynthesis: Chemical structure of chlorophyll a and b, absorption and action spectra, biological significance of carotenoid pigments, Red drop and Emerson effect, Components of photosystems (light harvesting complex), photochemical reaction centres, Cyclic and noncyclic

electron transport, Water splitting mechanism, Calvin cycle – Biochemical reactions & stoichiometry, HSK Pathway– three variants of the pathway, Photosynthetic efficiency of C_3 and C_4 plants and crop**productivity, Photorespiration – mechanism and significance, Crassulacean Acid Metabolism– mechanism and ecological significance.**

CO3. They will learn in details about Respiration: EMP pathway, regulation and its anabolic role, Conversion of Pyruvic acid to Acetyl CoA, TCA-cycle and its amphibolic role, Oxidative pentose phosphate pathway and its significance, Mitochondrial electron transport system, uncouplers, Oxidation of cytosolic $NADH+H^+$, Stoichiometry of glucose oxidation (aerobic).

CO4. Students will develop indepth concept regarding Nitrogen Metabolism: Assimilation of nitrate by plants, Biochemistry of dinitrogen fixation in Rhizobium, General principle of amino acid biosynthesis (including GS and GOGAT enzyme system).

CO5. They will learn about Lipid metabolism: synthesis and breakdown of triglycerides, ß-oxidation, glyoxalate cycle, gluconeogenesis and itsrole in mobilization of the lipids during seed germinbations, α- oxidation.

CO6. They will learn the mechanism of signal transduction: receptor-ligand interactions, second messenger concept,calcium-calmodilin, G protein, MAP-kinase cascade.

PRACTICAL- PLANT METABOLISM

CO1. Students will learn the techniques related to the following work-outs:

1. A basic idea of chromatography: Principle, paper chromatography and column chromatography;demonstration of column chromatography.
2. Separation of plastidial pigments by solvent and paper chromatography.
3. Estimation of total chlorophyll content from different chronologically aged leaves (young, matureand senescence) by Arnon method.
4. Effect of HCO_3 concentration on oxygen evolution during photosynthesis in an aquatic plant and tofind out the optimum and toxic concentration (either by volume measurement or bubble counting).
5. Measurement of oxygen uptake by respiring tissue (per g/hr.)6.. Determination of the RQ of germinating seeds.
7. Test of seed viability by TTC method.

DSE A3-
THEORETICAL- MEDICINAL AND ETHNOBOTANY

CO1. Students will gain knowledge in Medicinal botany: History, scope and

importance of medicinal plant, a brief idea aboutindigenous medicinal sciences- ayurveda, siddha and unani. Polyherbal formulations.

CO2. They will know about Pharmacognosy- General account : Pharmacognosy and its importance in modern medicine, Crude drugs, Classification of drugs- chemical and pharmacological, Drug evaluation– organoleptic, microscopic, chemical, physical and biological, Major pharmacological groups of plant drugs and their uses.

CO3. They will know in details about Secondary metabolites: Definition of secondary metabolites and difference with primary metabolites , Interrelationship of basic metabolic pathways with secondary metabolite biosynthesis (outlines only), Major types–terpenoids, phenolics, flavonoids, alkaloids and their protective action againstpathogenic microbes and herbivores.

CO4. They will know about Pharmacologically active constituents: Source plants (one example) parts used and uses of: Steroids (Solasodin, Diosgenin, Digitoxin), Tannin (Catechin), Resins (Gingerol, Curcuminoids), Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine), Phenols (Sennocide and Capsaicin).

CO5. Students will develop knowledge in Ethnobotany and folk medicine: Definition, methods of study, application, Indian scenario, national interacts, Palaeo-ethnobotany, folk medicines in ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India, application of natural products to certain diseases- Jaudice, cardiac, infertility, diabetics, blood pressure and skin diseases.

PRACTICAL- MEDICINAL AND ETHNOBOTANY

CO1. Students will perform work out and chemical tests on the following topics:

1. Chemical tests for (a) Tannin (*Camellia sinensis* / *Terminalia chebula*), (b) Alkaloid (*Catharanthusroseus*) .
2. Powder microscopy – *Zingiber* and *Holarrhena* .
3. Histochemical tests of (a) Curcumin (*Curcuma longa*), (b) Starch in non-lignified vessel (*Zingiber*), (c)

Alkaloid

(stem of *Catharanthus* and bark of *Holarrhena*).

DSE A4

THEORETICAL- STRESS BIOLOGY

CO1. Students will learn about Plant stress- definition. Acclimation and adaptation.

CO2. They will know about the Environmental factors- water stress, salinity stress and temperature stress- plant response. Pathogenesis- related (PR) proteins, systemic acquired resistance; mediation of insect and disease resistance by jasmonates.

CO3. They will gain knowledge about Stress sensing mechanism in plants: calcium modulation, phospholipid signaling.

CO4. They will gain knowledge regarding developmental and physiological mechanisms that protect plants against environmental stress: adaptation of plants, changes in root-shoot ratios, aerenchyma development; osmotic adjustment, compatible solute production.

CO5. They will learn about reactive oxygen species- production and scavenging mechanism.

PRACTICAL- STRESS BIOLOGY

CO1. Students will have the opportunity to gain first hand knowledge about:

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.

2. Superoxide dismutase activity in the absence and presence of stress.

3. Catalase activity in the presence and absence of stress.

4. Comparative study of plants/seedlings subjected to different degree of stress/ pollutants.

5. To study the effect of stress (salt/ water/ heavy metal) on seed germination and seedling growth (any commonly available specimen)

DSE B7

THEORETICAL- RESEARCH METHODOLOGY

CO1. Students will develop basic concepts of research: research- definition and types of research (Descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. emperical), research methods vs. methodology; literature-review and its consolidation; library research; field research; laboratory research.

CO2. They will become aware about the general laboratory techniques: common calculations in botany laboratories; understanding the details on the label of reagent bottles; molarity and normality of common amino acids and bases; preparation of solutions. Dilution, percentage, molar, molal and normal solutions. Techniques of handling micropipettes; knowledge about common toxic chemicals and safety measures in their handling.

CO3. They will develop skill about data collection and documentation of observations. Maintaining of laboratory records, tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

CO4. They will have an overview of biological problems: plant science research key areas, model organisms in research.

CO5. They will learn the methods to study plant cells/ tissue structure: whole mounts, peal mounts, squash preparations, clearing, maceration and sectioning, tissue preparation- fixation, dehydration etc., paraffin and plastic infiltration, preparation of thin and ultra-thin sections.

CO6. Students will develop valuable know-how regarding plant micro-techniques: staining procedures, classification and chemistry of stains, staining equipments. Cytogenetic techniques with squashed plant materials.

CO7. They will develop proficiency in the art of scientific writing and its presentation: numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power point presentation. Poster presentation. Scientific writing ethics. Introduction to copy write- academic misconduct/ plagiarism.

PRACTICAL- RESEARCH METHODOLOGY

CO1. Students will gain first hand skill about the following practical works:

1. Experiments based on calculations
2. Plant microtechnique experiments
3. The art of imaging of samples through photomicrography and field photography
4. Poster/ power point presentation on defined topics
5. Technical writing on topics assigned.

DSE B

THEORETICAL- Natural resource management

CO1. Students will learn about Natural resources: Definition and types.

CO2. They will know in details about Sustainable utilization: Concept, approaches (economic, ecological and socio-cultural).

CO3. Students will learn about land utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.

CO 4. Students will learn about water: Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands;Threats and management strategies.

CO5. They will learn in details about Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies;Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

CO6. They will know about Forests: Definition, Cover and its significance (with special reference to India); Major and minorForest products; Depletion; Management.

CO7. They will develop strong concept about Energy: Renewable and non-renewable sources of energy.

CO8. They will develop concept about Contemporary practices in resource management CO8. EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

CO9. They will know about various National and international efforts in resource management and conservation.

PRACTICAL- Natural resource management

CO1. Students will develop essential skills in the following procedures:

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Estimation of foliar dust deposition.
3. Determination of total solid in water (TDS)
4. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)
5. Estimation of organic carbon percentage present in soil sample.
6. Collection of data on forest cover of specific area.

GENERAL

SEMESTER I

CC 1

THEORETICAL- PLANT DIVERSITY I (PHYCOLOGY, MYCOLOGY, PHYTOPATHOLOGY, BRYOPHYTES AND ANATOMY)

CO1. Students will be Introduced to different plant groups.

CO2. Phycology: This course aims at acquainting students about the diagnostic characters and examples of selected groups of algae, they also learn about the classification and life-cycle of some algae in details. The students also develop concept about role of algae in the environment, agriculture, biotechnology and industry.

CO3. Mycology: This course aims at acquainting students about the diagnostic characters and examples of selected groups of fungi, they also learn about the classification and life-cycle of some fungi in details. The students also develop concept about role of fungi, mycorrhiza and lichens in the environment, agriculture, biotechnology and industry.

CO4. Phytopathology: Students get to learn about different terminologies and concepts prevalent in plant-disease study. They learn in details about the **s**ymptoms, causal organism, disease cycle and control measures of selected plant diseases.

CO5. Bryophytes: Students gain indepth concept about unifying features of archaegoniates and transition to land habit, amphibian nature of bryophytes, diagnostic characters and examples of major groups of bryophytes. They also learn in details about the life histories of selected genera of bryophytes. The also gain concept regarding the ecologic and economic importance of the group.

CO6. Anatomy: Students get to know in etails regarding the anatomical details of stomata, root, stem and leaf of monocots and dicots. They also have the scope to learn about different stelar types, their evolution and mode of secondary growth (both normal and anomalous) in selected plant genera.

PRACTICAL- PLANT DIVERSITY I (PHYCOLOGY, MYCOLOGY, PHYTOPATHOLOGY, BRYOPHYTES AND ANATOMY)

CO1. Work out: Students have hands-on experience in microscopic preparation, drawing and labeling of selected algal and fungal genera.

CO2. Anatomical studies: They have the exposure to undertake anatomical study with stem, root and leaf of selected plant genera.

CO3. They learn to identify different cryptogamic and plant disease specimens using observable characteristics.

CO4. Students are provided with scope to participate in local excursion where they can develop an in situ concept about plant diversity, habitat of algae and fungi etc.

Contact hours: 14hrs/week Practical: 10hrs/week

SEMESTER II

CC 2

THEORETICAL- PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY, MORPHOLOGY AND TAXONOMY)

Pteridophytes

CO1. Students gain detailed knowledge regarding major pteridophyte groups.

CO2. They also get to know in details regarding the life-history of selected pteridophyte genera.

CO3. They learn about the economic importance of pteridophytes.

Gymnosperms

CO1. Students gain detailed knowledge regarding major gymnosperm groups.

CO2. They also get to know in details regarding the life-history of selected gymnosperm genera.

CO3. They learn about the economic importance of gymnosperms.

Paleobotany & Palynology

CO1. Students have scope to learn in details regarding fossil, fossilization process, factors of fossilization and importance of fossil study.

CO2. They have a clear concept regarding the Geological time scale.

CO3. They gather useful concepts regarding palynology and its applications.

Angiosperm Morphology

CO1. Students learn in details regarding different types of inflorescence, flowers, fruits and seeds with examples.

Taxonomy of Angiosperms

CO1. Student get scope to develop in-depth concept regarding Artificial, Natural and Phylogenetic systems of c1assificaiton with example.

CO2. They get to learn about the diagnostic features of very carefully selected angiosperm families.

PRACTICAL- PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY, MORPHOLOGY AND TAXONOMY)

CO1. Students get the opportunity to dissect, draw and label, describe angiospermic plants from selected families. They also learn about floral parts, floral formula and floral diagram in details.

CO2. They get the scope to develop skill in identification of the plants.

CO3. Students learn to identify citing reasons pteridophyte, gymnosperm and various morphological and anatomical specimens (both macro- and

CO4. They learn to spot identify a number of selected Angiospermic plants belonging to different families.

CO5. Students have the opportunity to participate in field excursion to gain first-hand knowledge about the plants and plant-groups they hae studied in their class-room.

CO6. They learn the skills required to maintain field records and herbarium sheets of common Angiospermic weeds.

Contact hours: 5hrs/week Practical: 4hrs/week

SEMESTER III
CC-3
THEORETICAL- CELL BIOLOGY, GENETICS AND MICROBIOLOGY

CO1. Cell Biology and Genetics: Students will learn in details about the ultrastructure of nuclear envelope, nucleolus and their functions, Molecular organisation of metaphase chromosome (Nucleosome concept).
CO2. Chromosomal aberrations: They will know about deletion, duplication, inversion & translocation, Aneuploidy & Polyploidy-types, importance and role in evolution.
CO3. Central Dogma: Students will gain concept about Transcription and Translation.
CO4. Genetic Code- they will learn the properties.
CO5. Students will have elaborate idea about Linkage group and Genetic map (three-point test cross).
CO6. Mutation – They will have detailed understanding of Point mutation (tautomerisation; transition, transversion and frame shift), Mutagen-physical and chemical.
CO7. They will have a brief concept of Split gene, Transposons.

Microbes

CO1. Viruses- Students will know about the discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance.
CO2. Bacteria- They will know about the discovery, general characteristics and cell structure; reproduction- vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

PRACTICAL- CELL BIOLOGY, GENETICS AND MICROBIOLOGY

CO1. Cell Biology: Staining (Aceto-orcein) and squash preparation of onion root tip: study of mitotic stages. Determination of mitotic index (from onion root tip).
CO2. Microbiology: They will gain skill in the workout gram staining (curd/any natural source).
CO3. Identification with reasons: They will have the opportunity to observe Cytological slides of different mitotic and meiotic stages. Different forms of bacteria (Coccus, Bacillus, Spiral).

CO4. Laboratory Records: Students will learn how to maintain laboratory note books (regularly signed) and slides**.**

SEMESTER IV

CC-4

THEORETICAL- PLANT PHYSIOLOGY AND METABOLISM

CO1. Proteins: Students will gain detailed concept on primary, secondary and tertiary structure, Nucleic acid- DNA structure, RNA types, Enzyme- Classifications with examples (IUBMB), Mechanism of action.

CO2. Transport in plants: They will learn the mechanism behind Ascent of sap and Xylem cavitation, Phloem transport and source-sink relation.

CO3. Transpiration: They will learn the mechanism of stomatal movement, significance.

CO4. Photosynthesis: Students will learn in details about the Pigments, Action spectra and Enhancement effect, Electron transport system and Photophosphorylation, C3 and C4 photosynthesis, CAM- Reaction and Significance.

CO5. Respiration: They will learn in details about Glycolysis & Krebs cycle— Reactions and Significance, ETS and oxidative phosphorylation.

CO6. Nitrogen metabolism: They will know about biological dinitrogen fixation, Amino acid synthesis (reductive amination and transamination).

CO7. Plant Growth regulators: They will learn in details about Physiological roles of Auxin, Gibberellin, Cytokinin, Ethylene, ABA.

CO8. Photoperiodism: Students will come to know about plant types, Role of phytochrome and GA in flowering) and Vernalization.

CO9. Students will have a brief idea about Senescence.

PRACTICAL- PLANT PHYSIOLOGY AND METABOLISM

Plant Physiology:

CO1. Students will have hands on experience regarding **e**xperiment on Plasmolysis.

CO2. Students will have hands on experience regarding **m**easurement of leaf area (graphical method) and determination of transpiration rate per unit area by weighing method.

CO3. Students will have hands on experience regarding **i**mbibition of water by dry seeds - proteinaceous and fatty seeds.

CO4. Students will undertake experimental setups on evolution of O_2 during photosynthesis (using graduated tube).

CO5. Students will undertake experimental setups on evolution of CO_2 during aerobic respiration and measurement of volume.

SEMESTER V

DSE A (Group A)

THEORETICAL- PHYTOCHEMISTRY AND MEDICINAL BOTANY

CO1. Students will attain knowledge about medicinal botany- History, scope and importance of medicinal plants, a broef idea about indigenous medicinal sciences- Ayurbeda, Siddha and Unani. Polyherbal formulations.

CO2. Students will learn about Phramacognosy- Scope and its importance, Primary metabolites, Secondary metabolites- alkaloids, terpenoids, phenolics and their functions.

CO3. They will gain knowledge regarding Organoleptic evaluation of crude drugs.

CO4. They will know about Pharmcologically active constituents: Source plants (one example), parts used and uses of: 4.1 Steroids (Diosgenin, Digitoxin), Tannin (Catechin), Resins (Gingerol, Curcumnoids), Alkaloids (Strychnine, Reserpine, Vinblastine), Phenols (Capsaicin).

CO5. Students will gain knowledge about Ethnobotany and folk medicine: Brief idea, Applications of ethnobotany, Application of natural product to certain diseases- Jaundice, Cardiac and Diabetics.

PRACTICAL- PHYTOCHEMISTRY AND MEDICINAL BOTANY

CO1. Students will have hands on experience on the following procedures:

1. Preparations of solution and buffers
2. Acquaintance with laboratory instruments- Autoclave, Incubator, Clinical centrifuge, Analytical balance, pH meter, Colorimeter, Water bath, Distillation plant, Laminar air flow.
3. Qualitative test for proteins and carbohydrates, reducing and non reducing sugar (glucose, fructose and sucrose)
4. Tests (chemical) for tannin and alkaloid
5. Identification of medicinal plants (list to be provided)
6. Field study (local) and listing of medicinal plants. Records to be substantiated with photographs and description.

DSE A2

THEORETICAL- NATURAL RESOURCE MANAGEMENTS

CO1. Students will know about Natural resources- definition and types.

CO2. They will learn about sustainable utilization- concept, approaches (economic, ecological and socio-cultural).

CO3. They will have concept about land utilization. Soil degradation and management.

CO4. They will be able to conceptualize about water, fresh water, marine, estuarine. Wetlands- threats and management.

CO5. They will develop in-depth understanding about Biological resources, biodiversity- definition and types. Significance, threats and management strategies.
CO6. They will develop knowledge about Forests- definition, cover and its significance (with special reference to India). Major and minor forest products.
CO7. They will know about Energy- renewable and non-renewable source of energy.
CO8. They will know about EIA and waste management.

PRACTICAL- NATURAL RESOURCE MANAGEMENTS
CO1. Students will have first-hand experience through practical work regarding the following topics:
1. Estimation of solid waste generated by a domestic system (biodegradable and non- biodegradable) and its impact on land degradation.
2. Measurement of dominant woody species by DBH (diameter at breast height)
3. Study of community structure by Quadrat method and determination of minimal size of quadrat, frequency density and abundance of components to be done during field visit.
4. Measurement of dissolved O2 by azide modification of Winkler's method.
5. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)

SEC A
PLANT BREEDING AND BIOMETRY
CO1. Plant breeding: Students will have idea on **i**ntroduction and objective, Techniques of hybridisation.
CO2. Mass and Pure line selection: They will come to know about the Procedure, Advantages and limitations.
CO3. Students will learn about Heterosis and hybrid seed production.
CO4. They will come to know about the **r**ole of mutation, polyploidy, distant hybridization and role of biotechnology in crop improvement.
CO5. Biometry: Students will develop concept on Measures of central tendency (Mean, Median and Mode), Standard error and standard deviation, Test of significance: Chi-square test for goodness of fit.

BIOFERTILIZERS
CO1. Biofertilizers: Students will learn the **g**eneral account about microbes used as biofertilisers; Rhizobiumidentification, mass multiplication. Actinorrhizal symbiosis.

CO2. They will gain knowledge regarding *Azospirillum*- identification, mass multiplication, associative effect of different microorganisms. *Azotobacter* and crop response to *Azotobacter* inoculums.
CO3. They will learn in details about *Cyanobacteria, Azolla, Anabaena* and *Azolla* association, blue green algae and *Azolla* in rice cultivation.
CO4. They will gain idea about Mycorrhizal association: Types of Mycorrhizal association- Brief idea, Its influence on growth and yield of crop plants.
CO5. Organic farming: Students will gain knowledge about **g**reen manuring and organic fertilizers, Biocompost and vermicompost- making methods and field applications. Recycling of biodegradable municipal, industrial and agricultural wastes.

SEMESTER VI
DSE B
THEORETICAL- ECONOMIC BOTANY
CO1. Students will know about the origin of cultivated plants: Concepts of centres of origin and their importance with reference to Vavilov's work.
CO2. They will learn in details about Rice- origin, morphology and uses.
CO3. They will also learn in details about Legumes: General account with special reference to Vigna.
CO4. Students will know in details about Beverages: Tea- morphology, processing and uses.
CO5. They will undertake study of the following economically important plants (Scientific names, families, parts used and importance): Cereals- Rice, wheat, Pulses- Mong, gram, Spices- Ginger, cumin, Beverages- Tea, coffee, Medicinal plants- Cinchona, neem, Ipecac, Vasaka, Oil yielding plants- Mustard, groundnut, coconut, Vegetables- Potato, raddish, bottle groud, cabbage, Fibre yielding plants- Cotton, jute, Timber yielding plants- Teak, Sal; Fruits- Mango, apple, Sugar yielding plant- Sugarcane.

PRACTICAL- ECONOMIC BOTANY
CO1. Students will perform practical work on the following:

1. Study of economically important plants (rice/jute/ tea) through herbarium specimens and field study.
2. Study of cultivation practices in field and submission of report.
3. Study of local economically important plants and submission of report with photographs.

DSE B4
THEORETICAL- HORTICULTURAL PRACTICES AND POST HARVEST TECHNOLOGY

CO1. Students will learn about Horticulture- role in rural economy and employment generation. Urban horticulture- its scope and importance.
CO2. They will know about Ornamental plants- identification and salient features of some ornamental plants (rose, marigold, gladiolus, gerberas, tube rose, carnations, cacti and succulents). Ornamental flowering trees (Gulmohor, Lagerstromia, Shimul, Coral tree and jacaranda).
CO3. They will know the methods of identification of some fruits and vegetable plants- Citrus, Banana, Papaya, Mango, Jackfruit, Chillies and cucurbits. Fruit processing- scope and benefits.
CO4. Students will develop knowledge about horticultural techniques- propagation methods, application of manure, fertilizers, nutrients and PGR. Weed control. Biofertilizers and biopesticides.
CO5. They will have an in-depth concept of Post harvest technology- importance of post harvest technology in horticultural practices. Harvesting and handling of fruits, vegetables and cut flower. Methods of preservation and processing.
CO6. They will imbite knowledge about Disease control and management- field and post harvest diseases of common crops. Crop sanitation, quarantine practices. Identification of common diseases and pest of fruits and vegetable crops.

PRACTICAL- HORTICULTURAL PRACTICES AND POST HARVEST TECHNOLOGY
CO1. Students will participate in Field trips to gardens, standing crop sites, nurseries, vegetable gardens, horticultural fields and cold storages in order to gather first-hand knowledge about the topic.

SEC B3
THEORETICAL- PLANT BIOTECHNOLOGY
CO1. Students will know about Plant tissue culture- Introduction and basic concepts, Cellular potency, Callus culture and plant regeneration.
CO2. They will develop concept regarding Micropropagation- Somatic embryogenesis and artificial seed.
CO3. They will learn about Protoplast culture and its application.
CO4 They will have detailed idea about Recombinant DNA technology- Recombinant DNA, Restriction enzymes, Plasmids as vectors.
CO5. They will be able to conceptualize the procedures of Gene cloning (basic steps).
CO6. They will know about the achievements in crop biotechnology- 6.1 Pest resistant plant (Bt cotton), 6.2 Transgenic crops with improved quality (flavr tomato and golden rice).

SEC B4

THEORETICAL- MUSHROOM CULTURE TECHNOLOGY

CO1. Students will know in ndetails about Mushroom- nutritional and medicinal value of mushrooms. Poisonous mushrooms.

CO2. They will learn in details about the cultivation techniques/ technology of edible mushrooms in India: *Volvarealla volvacea, Pleuretus citrinopyrineatus, Agaricus bisporus.*

CO3. They will know about the storage- short term and long term, storage, drying.

CO4. They will have details knowledge about food preparation- types of foods prepared from mushroom. Cost and benefit ratio.

CO5. Students will gain information about research centres- national and regional.

Under 1+1+1 System
PART II
HONOURS

PAPER III
THEORETICAL- Pteridophytes, Gymnosperms, Ecology and Plant Geography, Anatomy
PTERIDOPHYTES
1.General account of Pteridophytes.
CO1. Understanding the general characters, structure, reproduction, life cycle pattern.
1.1.Colonisation and rise of early land plants.
CO1. Understanding the origin of sporophyte land plants, and their colonization.
1.2.Classification of Vascular Plants by Gifford and Foster (1989) up to division (Rhyinophyta to Filicophyta) with diagnostic characters and examples.
CO1. Understanding the arrangements of vascular plants in taxonomic groups according Gifford and Foster from Rhyinophyta to Filicophyta with their diagnostic characters with examples.
2. Life history.
CO1. Undestanding about occurrence ,distribution and life cycle pattern about different genera of pteridophytes.
Sporophyte structure, Reproduction and Gametophyte structure in 2.1Psilotum.2.2 Selaginella 2.3 Equisetum 2.4 Dryopteris.
CO1. Understanding the structure of both phases sporophytic and gametophytic and reproduction in genus Psilotum,.Selaginella,Equisetum and Dryopteris.
3. Fossil Pteridophytes.
CO1. Undestanding about the origin, classification, structure of fossil pteridophytes.
Structural features, Geological distribution and Evolutionary significance of 3.1 Rhynia.3.2 Lepidodendron.3.3 Calamites.
CO1. Understanding the morphological, anatomical features their distribution and evolutionary significance of Rhynia, Lepidodendron, and Calamites.
4. Telome concept and its significance in the origin of different groups of Pteridophytes.
CO1. Understanding the theory that the megaphylls of ferns and seed plants evolved by the modification of the terminal branches of stems and their significance in different genera of pteridophytes.
5. Hetrospory and Origin of seed habit.
CO1. Understanding the production of two or more type of spores in a single plant and Origin of seeds and seed habit in vascular plants from hetrospory.
6. Economic importance as food, medicine and Agriculture.
CO1. Undestanding economic use of pteridophytes as food medicine and in agriculture.

GYMNOSPERMS.

1 .Classification of vascular plants by Gifford and Foster (1989) up to division (progymnospermophyta to Gnetophyta) with diagnostic characters and examples.

CO1. Understanding the classification from earlier woody plants to advanced group of gymnosperms by Gifford and Foster, with their general characters like habit, occurrence, structure with examples.

2. Progymnosperms.

CO1. Understanding about earlier woody plants.

2.1. Diagnostics Characters of the group 2.2.Vegetative and Reproductive features of Archeopteris.2.3. Phylogenetic importance.

CO1. Understanding the important characters of progymnosperms morphological, anatomical and reproductive characters of Archeopteris.And their evolutionary importance.

3. Life History.

CO1. Understanding the occurrence, distribution, life cycle pattern in gymnosperms.

Distribution in India, vegetative and reproductive structure, Development of gametophyte and Embryogeny in 3.1 Cycas.3.2 Pinus.3.3 Gnetum.

CO1. Understaning the distribution of genus Cycas, Pinus and Pnetum in India their vegetative and reproductive structure of sporophyte and gametophytes development.

4. Fossil Gymnosperms.

CO1. Understanding general account of fossil gymnosperms.

Structural features and Geological distribution of reconstructed genera: 4.1 Lyginopteris.4.2 Williamsonia.4.3 Cordaites.

CO1. Understanding the distribution of Lyginopteris, Williamsonia, and Cordaites according to geological time scale, and their structure.

5. Economic Importance with reference to wood, Resins, Essential oils and Drugs.

CO1. Understanding the economic importance of gymnosperms relating wood used as furnitures, essential oils and drugs.

ECOLOGY

1. Preliminary idea on:

CO1. Understanding the primary ideas on ecosystem.

1.1Habit and Niche, Ecotone and edge effect, 1.3 Microclimate, 1.4Ecads ecotypes and ecoclines, 1.5 Carrying capacity.

CO1. Undestanding ecological habit the specific area where organism inhabits, transitional areaof vegetation between two different plant communities, climate of very small area which differ from the surrounding, distinct form or race plant species occupying particular habitat.

2. Community ecology:

CO1. Understanding about different communities of ecosystem.

2.1. community-characteristics and diversity.

CO1. Understanding the diversification of different communities with characters.

2.2. Ecological Succession- Primary and secondary, seral stages, autogenic and allogenic succession

CO1. Understanding the process of change in species structure of ecological community, seral stages, and succession driven by biotic and abiotic components.

3.3.1. Plant indicators; 3.2 .Phytoremediation.

CO1. Understanding the indicator species respond closely to metal concentration and bioremediation of various plants to remove, transfer, and destroy the contaminants in soil and groundwater.

4. Conservation of Biodiversity.

CO1. Understanding the conservation of biodiversity.

4.1. Level of Biodiversity: genetic species and ecosystem diversity.

CO1. Understanding the three levels of biodiversity genetic, species and ecological.

4.2. Biodiversity hotspots-criteria, Indian hotspots

CO1. Understanding the criteria to qualify as a biodiversity hotspots and Indian hotspots.

4.3. In-situ and Ex-situ conservation, 4.4 Seed-banks, 4.5.Cryopreservation, 4.6 Geographic Information system and remote sensing (brief idea)

CO1. Understanding the conservation of plants species in their natural and outside the natural habitats store the seed to preserve genetic diversity and use of very low temperature to preserve the structure of living cell intact.

PLANT GEOGRAPHY

5: Phytogeographical regions:

CO1. Understanding the area of uniform climatic conditions and having distinct types of vegetation.

5.1. Phytogeographical regions of India (chatterjee 1960);5.2 Dominant flora of Eastern and Western Himalaya and Sunderban.

CO1. Understanding the different phytogeographical regions of India according to Chatterjee and knowing about dominant plants of Eastern western and Sunderban areas.

6. Endemism:

CO1. Understanding the ecological state of a species being unique to a particular habitat.

6.1. Endemism types and Factors; 6.2.Age and Area hypothesis Epibiotic theory; 6.3.Endemism in Indian flora.

CO1. Understanding different types of Endemism factors area hypothesis, different theory of Epibioticc and endemism in Indian plants.

ANATOMY

1. Cell wall

1.1. Ultrastructure and chemical constituents.

CO1. : Understanding fine detail structure of cell wall and its composition.

1.2Plasmodesmata ultra structure.
CO1. understanding about fine structure of cytoplasmic canal that passes through plant cell walls.
1.3.Concept of apoplast and symplast.
CO: Understanding the movement of water and solute through protoplasmic and nonprotoplasmic parts.
1.4. Growth and thickening of cell wall.
CO1. Understanding the modification of cell according to function they perform and parts like xylem phloem undergo heavy thickening of their walls.
2. STOMATA.
21. Types and 2.2 Ontogeny.
CO1. Understanding the different types and origination and development of stomata.
3. Ontogeny of 3.1 Trachea and 3.2 Sieve tube.
CO1. Understanding the origination and development of Xylem vessels and living part of phloem.
4. Stele. 4.1 Leaf trace and Leaf gap.4.2 stellar types and its evolution.
CO1. Understanding the extension of vascular tissue from stem into the leaf and space from which leaf grows and types of stele and its origin and evolution.
5. Secondary growth:
CO1. Understanding the increase in thickness of the plant parts due to the activity of vascular cambium and cork cambium.
5.1 .Normal (intrastelar and extrastelar).
CO1. Understanding the secondary growth in stelar region by vascular cambium and in cortex due to cork cambium.
5.2. Anomalous (stem of Bignonia, Boerhavia, Tecoma, Dracaena and root of Tinospora).
CO1. Understanding the abornormality of cambium tissue in different Genera.
6. Mechanical tissue and principles governing their distribution in Plants.
CO1. Understanding the principles regarding the construction of mechanical tissue and their distribution.
7. Developmental Anatomy:
CO1. Understanding the structural changes of an plant from initial stage to its maturity.
7.1. Organisation of shoot apex (Tunica-corpus) and root apex (Korper-Kappe).
CO1. Understanding the developmental and organisation of shoot and root apex based on the theories concerned on plane of cell division.
7.2. Plastochron.
CO1. Understanding the time interval between initiations of leaf growth between two consecutive nodes in a growing shoot apex.
8. Ecological Anatomy:
CO1 Understanding the anatomical adaptation by group of plants species under the stress condition.
Adaptive anatomical featuresof 8.1.Hydrophytes 8.2. Xerophytes.

CO1. Understanding the anatomical characters of plants living in dry condition and in water for the adaptation.

PAPER IVA

THEORETICAL- Morphology of Angiosperms, Taxonomy of Angiosperms

MORPHOLOGY OF ANGIOSPERMS

1. Inflorescence types with examples.

CO1. Understanding about the different types of arrangement of flower on floral axis.

2. Flower: Corolla- forms, aestivation; Stamen- types; Placentation-types; Ovule - structure and forms.

CO1. Describing and understanding different parts of flower including different whorls, types of placentation and ovule.

3. Fruit - types with examples.

CO1. Describing different types of fruits along with its classification according to different aspects.

TAXONOMY OF ANGIOSPERMS

1. Introduction :

1.1. Components of Systematics: Nomenclature, Identification, Classification; 1.2. Taxonomy and its phases -Pioneer, Consolidation , Biosystematic and Encyclopaedic ; alpha- and omega- taxomony .

CO1. Understanding about the conception of biosystematics in detail including basic knowledge of taxonomy.

2. Nomenclature :

Elementary knowledge of ICBN: Principles; Rank of taxa, Retention and rejection of names; Type method; Principleof priority; Effective and valid publication; Author Citation.

CO1. Knowing about the rules and regulation of botanical code along with nomenclatural type method.

3. Systems of classification :

Broad outline of Bentham & Hooker (1862-1883), Cronquist's (1988) system of classification with merits and demerits

CO1. Discussing the classification system of plants according to different authors and their merits and demerits.

4. Systematics in Practice :

4.1. Herbaria and Botanical Gardens – their role; important Indian Herbaria and Botanical Gardens; 4.2. Dichotomouskeys – indented and bracketed.

CO1. Study the methods of plant exploration, collection, preparation of herbarium and its identification by using different keys. Also know about the Herbaria and Botanical Garden.

5. Phenetics and Cladistics :

Brief idea on Phenetics, Numerical taxonomy; Cladistics; Monophyletic, polyphyletic and paraphyletic groups;Plesiomorphy and apomorphy.

CO1. Establishing the relationship among ancestral plants with its descendent by using different methods particularly Phenetics and Cladistics.

6. Data sources in Taxonomy:

Supportive evidences from : 6.1. Phytochemistry, 6.2. Cytology, 6.3. Anatomy.

CO1. Study of different data sources of taxonomy and its different supporting evidences.

7. Diagnostic features, Systematic position (Bentham & Hooker and Cronquist), Economically important plants (parts used and uses) of selected families.

CO1. Discussing Salient features of different Dicotyledons and Monocotyledons plant families and their importance.

PAPER IVB

PRACTICAL

1. Workout on Pteridophytes

CO1. Critically analyzing and understanding the important cellular structure of different pteridophytes and tracing the evolutionary lineage of this particular plant group and also correlating with other group of plants.

2. Workout on Angiosperms

CO1. Learning the process of plant dissection, illustration, description and diagnosis and also identifying the plant with the help of different floras including the procedure of handling the different types of keys.

3. Spot Identification

CO1. Examining critically the different plant parts particularly cellular structure and identify them through microscope or by naked eyes.

4. Identification with reasons (Pteridophyte - 1, Gymnosperms - 2, Palaeobotany/Palynology–1,)

CO1. Investigating critically the different microscopic or macroscopic plant parts or plant body and identify them using proper reason.

Contact hours: 5hrs/week Practical: 6hrs/week

PART-II
GENERAL

Paper-II

Theoretical-Module III: Anatomy, Cell Biology and Genetics.

Module IV:Biochemistry and Plant Physiology, Economic Botany, Ecology.

1. Anatomy:

CO1. Classification of different types of stomata and understanding the detail cellular structure of different types of stele, roots, stems and leaves of monocots and dicots plant along with is anomalous secondary growth.

2. Cell Biology and Genetics:

CO1. Understanding the different cytological structure particularly nuclear envelope, nucleolus, chromosome and DNA. Understanding the mechanism of DNA replication, transcription and Translation and also the process of chromosomal abaration along with different types of cytological event related to Chromosome, DNA and gene.

3. Biochemistry and Plant Physiology:

CO1. Understanding the different macromolecular structure of different biochemical process of plant cell including structure of protein, enzyme. Also understanding the different physiological processes of plant and its effects. Besides knowing the structure and functions of different plant hormones.

4. Economic Botany:

CO1. Study of different economically important plants including their scientific names, families, partsused and importance.

5. Ecology:

CO1. Understanding about the ecological system including its different factors. Also knowing about the biodiversity and its conservation and Phytoremediation.

Paper-III

Practical

Module V

1. Cryptogams:

CO1. Understanding the vegetative and reproductive structure bythe process of microscopic slide preparation, drawing and labeling, description and identification of them.

2. Angiosperms:

CO1. Learning the process of plant dissection, illustration, description and diagnosis and also identifying the plants.

3. Identificaiton with reasons:

CO1. Examining critically the different plant parts particularly cellular structure and identify them through microscope or by naked eyes.

4. Spot identification

CO1. Examining critically and identifying the different plants and its family by their diagnostic characters.

Module VI

1. Plant Physiology:

CO1. Examining the different physiological processes of plants.

2. Anatomy:

CO1. Critically analyzing and understanding the important cellular structure of different plant parts and identifying them by their diagnostic characters.

3. Cell Biology:

CO1. Knowing the process of preparation of squash and study of mitotic stages and determination of mitotic index.

4. Identificaiton with reasons:

CO1. Examining the different mitotic and meiotic stages by using its critical characters.

Contact hours: 5hrs/week Practical: 6hrs/week

PART III

HONOURS

PAPER V (THEORETICAL)

BIOCHEMISTRY

CO1. Biochemical Foundations:

Students will get an idea about various types of bonds, pH,Buffer solution, structure and properties of water.

CO2. Molecules of life

Study about nucleic acids, B and ZDNA, RNA, Nucleotides and nucleosides, biochemistry of proteins, carbohydrates and lipids.

CO3. Energy flow and enzymology :

To understand Bioenergetics-Thermodynamic principles, Biological redox reactions, Enzymes – classification and nomenclature enzyme action and Enzyme kinetics

CO 4. Cell membrane and Biosignalling :.

Study about Membrane chemistry, transport , Signal transduction pathway and second messenger concept - G-protein and Ca2+ as messenger.

CO 5. Phosphorylation :

Gives an overview of ATP synthesis (Chemiosmotic theory)and differences between oxidative and photophosphorylation

PHARMACOGNOSY

CO1. Gives a. general account of Pharmacognosy and its importance in modern medicine, Crude drugs, Classification of drugs, Drug evaluation

CO2. Secondary metabolites :

Definition of secondary metabolites, basic metabolic pathways with secondary metabolite biosynthesis Major types– with examples.

CO 3. Pharmacologically active constituents :

To study about Source plants, parts used and uses of some secondary metabolites.

PLANT PHYSIOLOGY

CO1. Plant-water relations:

To examine the Concept of water potential, Soil-plant-Atmosphere continuum concept, Transpiration and stomatal physiology.

CO2. Organic translocation

To focus about phloem transport and various hypothesis about Organic Translocation and its critical evaluation.

CO3. Photosynthesis :

The students will understand about the photosynthetic pigments ,importance, components, process and stages of photosynthesis with details of various pathways C3, C4,and CAM and their differences with stoichiometry and their ecological significance and photorespiration .

CO4. Respiration:

To evaluate the respiration process, various phases, regulatory steps ,site of respiration, types of respiration mitochondrial ETS and stoichiometry of glucose oxidation(aerobic)..

CO5. Nitrogen Metabolism :

Students will be given an idea of Assimilation of nitrate by plants, Biochemistry of dinitrogen fixation in Rhizobium, and General principle of amino acid biosynthesis (including GS and GOGAT enzyme system).

CO6. Plant Growth Regulators :

To assess and describe about Physiological roles of (Growth regulators) Auxin, Gibberellin, Cytokinin, Abscisic acid, Ethylene ,Chemical nature –IAA, GA3,Kinetin, Biosynthesis and bioassay of IAA, Mode of action of IAA, Brassinosteroids and Polyamines as PGRs (brief idea).

CO7. Photomorphogenesis :

To know about the concept of photomorphogenesis Photoperiodism Phytochrome, Role of GA in flowering, Vernalisation Concept of biological clock and biorhythm .

CO8. Seed dormancy :

Students will study the Types; Causes and Methods of breaking seed dormancyBiochemistry of seed germination.

CO9. Physiology of Senescence and Ageing.

This topic will help the students understand briefly about plant senescence and ageing process.

CO10. Stress Physiology

The students will be made aware of Plant responses to Water stress, Temperature stress and Salt stress.

PAPER VI

1. CELL BIOLOGY

CO1. Origin and Evolution of Cells :

Students will get idea about origin of cells, and origin of (cp-and mt-DNA).

CO2. Nucleus and Chromosome :

An elaborative structure for students regarding detailed idea about nuclear structure and ribosomebiogenesis and chromosomal and DNA structure.

CO3. Cell cycle and its regulation :

A detailed idea about cell cycle mechanism in yeast and its checkpoints and its related mechanism of apoptosis

PLANT BREEDING & BIOMETRY

CO1. Plant Breeding:

An idea for students about Molecular Breeding (use of DNA markers in plant breeding), Mass selection and Pure line selection and Heterosis and hybrid seed production

CO2. Biometry:

An idea for students about biostatistical measures, biostatistical analysis methods, Test of significance: 't'- test; chi square test for goodness of fit, Probability and Measurement of gene frequency (Hardy-Weinberg equilibrium).

PLANT BIOTECHNOLOGY

CO1. Plant tissue culture –

An Introduction to Plant tissue culture method and the requirements for tissue culture

CO2. Callus culture:

A detailed idea for students about the process for callus culture and its maintenance.

CO3. Micro propagation:

The students will get an idea about Organogenesis (direct and indirect), Somatic embryogenesis, Artificial seed, and its significance.

CO4. Haploid Culture:

A detailed process for students about Anther and Pollen culture methods, and its significance .

CO5. Protoplast Culture:

A clear picture about the method of Protoplast isolation, culture, Protoplast fusion (somatic hybridization) and its Significance.

CO6. Plant Genetic Engineering:

A detailed idea about achievements of plant genetic engineering and outcome of technology that is production of transgenic crops.

GENETICS & MOLECULAR BIOLOGY

CO1. Linkage, Crossing over and Gene Mapping :

Detailed idea for students about of Detection of crossing over (McClintock's experiment), Molecular mechanism of crossing over (Holliday model) and the process of Gene mapping.

CO2. Epistasis and Polygenic inheritance in plants.

The students will get an idea about Aneuploidy and Polyploidy and its application on agriculture

CO4. Chromosomal aberration:

Students will be benefitted about the types and the application of meiotic behavior of Deletion, Duplication, Translocation and Inversion.

CO5. Mutation :

The students will get an idea about mutation and molecular mechanism of mutation types and DNA repair and its mechanism.

CO6. Structural organization of Gene :
A detailed idea for the students about structure and organization different types of gene for example Overlapping gene,Repetitive DNA-tandem and interspersed,Transposon (Ac-Ds system)and Homoeotic gene in plants (ABCmodel in Arabidopsis).
CO7. DNA Replication, Transcription and Translation (Prokaryotes & Eukaryotes):
An idea for students about the basic process of a living cell , the central dogma, its detailed process, enzymes involved and RNA processing.
CO8. Gene Regulation :
Students will get idea about concept of Lac-operon, and its Positive and negative control.
CO9. Genetic Code :
A structure about Properties-evidences & exceptions of genetic code
CO10. Recombinant DNA Technology
Detailed idea for students about DNA technology its applications .The enzymes involved in the process of DNA technology, marker genes, and formation of Genomic DNA and C- dna library are quiet beneficial for the students.
CO11. Bioinformatics: Brief concept on 11.1 Genomics, 11.2 Proteomics.

Paper VII
Practical

PLANT BIOCHEMISTRY
CO1. Students will get hands- on practical experience in Qualitative estimation of organic acids, carbohydrate and protein estimation from plant products, detect the nature of carbohydrate from laboratory samples and detect mineral nutrients from plant ash.
CO2. Students will also have practical experience in Quantitative estimation of amino nitrogen, glucose, TAN, enzyme activity(catalase and urease),and colorimetric estimation of protein.
PLANT PHYSIOLOGY
CO1. Students will be exposed and be able to carry out various plant physiological experiments themselves and learn about methodology of plant physiological experiments on Imbibition, measurement of osmotic pressure, transpiration and evaporation, stomatal frequency, photosynthesis ,separation of plastidial pigments, respiration and about parameters like Q10.
ANATOMY
CO1. Students will gain an insight on anatomical features of plant cells, stomatal morphology through microscopic studies.
CO2. Students will learn about the anatomical features with special emphasis on Anamolous secondary growth of stem and root sections.
CO3. Study and note the adaptive anatomical features of Hydrophytes and Xerophytes.

PHARMACOGNOSY

CO1. Perform and learn about chemical tests on Tanin and Alkaloids.

CO2. Students will have hands-on experience on practical metholodology on powder microscopy using Zingiber and Holarrhena.

CO3. Perform and learn about Histochemical tests on Curcumin, Starch , and Alkaloid.

PAPER VIII

CELL BIOLOGY AND GENETICS

CO1. Detailed idea for students about the process of evaluation of mitotic index, idea about the stages of mitosis and meiosis, Study of mitotic chromosome : Metaphase chromosome preparation from from root tips: Allium cepa , Aloe vera , Lens esculenta. Identification from permanent slides gives detailed and clear idea about how and why the chromosomal abnormalities happen and how they look like.

BIOMETRY

CO1. It gives students an idea about the process of determination of goodness of fit in normal and modified mono-and dihybrid ratios by Chi-square analysis and on the nature of inheritance.

Contact hours: 11hrs/week Practical: 10hrs/week

PART-III
GENERAL
THEORETICAL

Paper-IVA

Module VII

Biofertilizer:

CO1. Detailed information about the sources , production and application of biofertilizer

Mushroom:

CO1. Students are benefitted with the idea about how the common edible mushrooms are cultivated and used as food.

Plant disease control:

CO1. Students get an idea about the common plant disease and their control measures both chemical and biological along with its quarantine methods

Plant Breeding:

CO1. An idea for students about Mass and Pure line selection, Heterosis and hybrid seed production .

Biometry:

CO1. Biometrical methods are studied by the students along with Measures of Central Tendency and Goodness of fit (Chisquaretest).

Plant tissue culture:

CO1. Detailed idea about study of artificial method of plant tissue culture along with micro propagation, Somatic embryogenesis, artificial seed and protoplast culture with its applications.

Pharmacognosy:

CO1. An elaborative idea about scope and importance of Secondary metabolites- alkaloids, terpenoids, phenolics and their functions, along with their organoleptic evaluation of crude drugs.

Paper IVB

Practical

Module VIII

CO1. Students will be acquainted with laboratory instruments and their working principle with practical knowledge of handling these instruments.
CO2. Students will learn about sterilization techniques by autoclaving.
CO3. Students will learn about preparation of PDA medium.
CO4. Students will have hands-on experience on Bacterial staining techniques with suitable staining methods from curd.
CO5. Students will be acquainted with common medicinal parts and their uses.
CO6. Determine the method of Goodness of Fit of normal Monohybrid ratios by Chi Square analysis.
CO7. Students will be taken to visit Medicinal Plant Garden and learn to prepare a field report.

Contact hours: 4hrs/week Practical: 6hrs/week

PROGRAMME OUTCOME

PO1. Students will be able to apprehend of the range of plant diversity spanning from simple algae to angiosperms through interim groups like fungi, bryophytes, pteridophytes and gymnosperms. Students are provided with the scope to understand the evolutionary events that lead to the origin of these diverse forms. They also have the scope to ascertain the phylogenetic relationship between different groups of plants.

PO2. Students will learn in details about lower groups like prions, viroids, viruses and bacteria. They will gain knowledge regarding their economic and ecologic implications.

PO3. Students will be trained in skills required to plant diseases, causal organisms, and their life-cycle. They will be able to come up with appropriate suggestions to control those diseases.

PO4. They will learn in details about the anatomical features of plant.

PO5. Students will gain in-depth knowledge about palaeobotany, palynology and the ecologic and economic applications of these fields of study.

PO6. Students will be able to know in details about the reproductive biology of angiosperms, plant geography, ecology and evolution of plants.

PO7. Students will be made aware regarding the latest aspects of genetics, cell and molecular biology.

PO8. They will learn about the different topics and procedures of plant-physiology and biochemistry.

PO9. Students will get to know the ecologic and economic importance of studying Botany.

PO10. Students can choose from topics like applied phycology, mycology and microbiology, biofertilizers, plant breeding and mushroom culture technology as their 'Skill Enhancement Course' as per their interest.

PO 12. Based on their aptitude they have the choice to opt from biostatistics, industrial and environmental microbiology, medicinal and ethnobotany, stress biology, plant biotechnology, horticultural practices and post-harvest technology, research methodology and natural resource management as their 'Discipline Specific Elective Course'.

PROGRAMME SPECIFIC OUTCOME

PSO1. Students will learn in details about lower groups like prions, viroids, viruses and bacteria. They will gain knowledge regarding their economic and ecologic implications.

PSO2. Students will learn in details about algae, their organization, classification, characteristics, ecologic and economic importance etc.

PSO3. Students will learn in details about fungi, their organization, classification, characteristics, ecologic and economic importance etc.

PSO4. Students will learn in details about bryophytes, their organization, classification, characteristics, ecologic and economic importance etc.

PSO5. Students will learn in details about pteridophytes, their organization, classification, characteristics, ecologic and economic importance etc.

PSO6. Students will learn in details about gymnosperms, their organization, classification, characteristics, ecologic and economic importance etc.

PSO7. Students will learn in details about angiosperms, their organization, classification, characteristics, ecologic and economic importance etc.

PSO8. Students will develop skill in identifying plant diseases. Identify plant diseases and come up with appropriate measures to treat them.

PSO9. They will learn in details about the anatomical features of different plant parts and identify normal and anomalous tissue arrangement from sections of plant parts.

PSO10. Students will gain in-depth knowledge about geological time scale, fossils, fossilization process, past vegetation and past climate.

PSO11. They will learn in details about spores and pollens in details, their morphological features, classification and application in various fields.

PSO12. Students will be able to know in details about the reproductive biology of angiosperms.

PSO13. Students will gain in-depth knowledge about plant geography, ecology and evolution of plants.

PSO14. They will have a detailed idea regarding the economic scope offered by botany.

PSO15. Students will be made aware regarding the different aspects of genetics, procedures and applications.

PSO16. They will learn in extensive details about cell and molecular biology.

PSO17. They will learn about the different topics and procedures of plant-biochemistry and also know about their applications.

PSO18. Students will have elaborate knowledge about plant physiology and metabolism that will help them in better apprehension of the physiological activities of plants.

PSO19. Under the CBCS curriculum students have the flexibility to choose from very up to date topics like applied phycology, mycology and

microbiology, biofertilizers, plant breeding and mushroom culture technology as their ‘Skill Enhancement Course’. This is definitely a welcome opportunity for all of them to choose based on their interests.

PSO 20. Under the ‘Discipline Specific Elective Courses’ they have the choice to opt from biostatistics, industrial and environmental microbiology, medicinal and ethnobotany, stress biology, plant biotechnology, horticultural practices and post-harvest technology, research methodology and natural resource management depending on their aptitude and interest.