



Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Annexure-1b

Discipline Specific Core (DSC) Course:

5CC-BT-01: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Plant Ecology and Phytogeography (Practical)

- Unit 01.** Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
- Unit 02.** Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper).
- Unit 03.** Estimation of dissolved oxygen content from water samples (Using kit).
- Unit 04.** Determination of minimal quadrat size for the study of herbaceous vegetation in the institute campus, by species area curve method (species to be listed).
- Unit 05.** Quantitative analysis of herbaceous vegetation in the institute campus for frequency and comparison with Raunkier's frequency distribution law.
- Unit 06.** Study of morphological adaptations of hydrophytes through photographs.
- Unit 07.** Study of morphological adaptations of halophyte and xerophytes through photographs.
- Unit 08.** Ecological anatomy- Study of anatomical features of *Hydrilla* stem, *Nymphaea* petiole (hydrophytes), *Nerium* leaf (xeromorph) and *Vanda* root (epiphytes).
- Unit 09.** Study of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobancha*), Epiphytes (*Vanda*), Predation (Insectivorous plants) through photographs.
- Unit 10.** Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
- Unit 11.** Measurement of dominance of woody species by DBH(diameter at breast height) method.
- Unit 12.** To prepare map showing vegetation of West Bengal, Major Climatic Zones and to comment on it.
- Unit 13.** To prepare map showing vegetation of biogeographical regions of India and to comment on it.
- Unit 14.** Field visit to an agroclimatic regions (mandatory for each student)

5CC-BT-02: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Ecology and Phytogeography (Theory)

Module I: Plant Ecology

- Unit 01.** Plant Ecology- definition, branches, relevance to human civilization.
- Unit 02.** Ecosystem- concept and types of ecosystems, components –biotic and abiotic, energy flow.
- Unit 03.** Nutrients cycling (carbon, nitrogen, phosphorous), biotic interrelationship.
- Unit 04.** Plant communities- definition, habitat and niche, ecotone and edge effects, importance of Keystone species, community dynamics and plant succession types: primary and secondary successions.
- Unit 05.** Ecological factors: soil- water, light and temperature; concept of limiting factors.
- Unit 06.** Atmosphere and plant responses-I: Morphological, anatomical and physiological adaptations of Halophytes and Xerophytes.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 07.** Atmosphere and plant responses-II: Morphological, anatomical and physiological adaptations of Hydrophytes.
- Unit 08.** Atmosphere and plant responses-III: Psammophytes, Lithophytes, Psychrophytes, Succulents and their morphological adaptations.
- Unit 09.** Environmental pollution: air pollution, water pollution and their impact on plants.
- Unit 10.** Global environmental issues: greenhouse gases, global warming, ozone depletion, acid rain, EL-Nino and La-Nino.

Module II: Phytogeography

- Unit 11.** Phytogeographical zones of India according Rodgers & Panwar (1988).
- Unit 12.** Endemism: definition, types, causes of endemism, endemic flora of India.
- Unit 13.** Flora of Eastern Himalaya.
- Unit 14.** Flora of western Himalaya.
- Unit 15.** Flora of Sundarbans.
- Unit 16.** Definition of Biodiversity, Levels of Biodiversity, Importance of Biodiversity, causes of depletion of Biodiversity, Biodiversity hotspots; IUCN, Red List of threatened species, threatened plants of India; Red Data book.
- Unit 17.** Plant conservation: Significance of conservation, ex-situ and in-situ conservation; biosphere reserve; wildlife sanctuary; national park.

6CC-BT-03: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Phycology and Microbiology (Practical)

- Unit 01.** Microscopy and Micrometry.
- Unit 02.** Study of plaque formation of bacterial lawn on petri plates through photographs.
- Unit 03.** Types of Bacteria to be observed from temporary/permanent slides/photographs.
- Unit 04.** Preparation of Culture Media (slants and stabs).
- Unit 05.** Sterilization and inoculation techniques.
- Unit 06.** Bacterial Sample Preparation and Gram Staining.
- Unit 07.** Microscopic Observation of curd microflora using gram staining methods.
- Unit 08.** Root nodulating bacteria: Microscopic observation of nodulating bacteria.
- Unit 09.** Study of endospores (*Bacillus cereus*, *B. subtilis* and *Corinebacterium diptheriae*, may be cited as centrally, sub-terminally and terminally located endospores) using photographs.
- Unit 10.** Preparation and identification: *Nostoc* & *Gloetrichia*.
- Unit 11.** Preparation and identification: *Volvox* & *Oedogonium*.
- Unit 12.** Preparation and identification: *Coleochaete* & *Chara*.
- Unit 13.** Preparation and identification: *Vaucheria* & *Ectocarpus*.
- Unit 14.** Preparation and identification: *Fucus* & *Polysiphonia*.
- Unit 15.** Study of some plant viral diseases (mosaic and vein-clearing).

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

6CC-BT-04: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Mycology and Phytopathology; Archegoniate; Paleobotany (Practical)

- Unit 01.** Introduction to the world of fungi (Unicellular, coenocytic / septate mycelium, ascocarps & basidiocarps) through photographs.
- Unit 02.** Work out and identification: *Rhizopus*, *Penicillium*, *Ascobolus* and *Agaricus*.
- Unit 03.** Study of reproductive stages of *Puccinia* from permanent slide.
- Unit 04.** Study of morphological types of Lichens.
- Unit 05.** Study of Mycorrhizae: internal structure; ectomycorrhiza and endomycorrhiza through Photographs.
- Unit 06.** Preparation of Culture Media (slants and stabs) and isolation of a fungal specimen.
- Unit 07.** Study of some diseased plant specimens: Late blight of potato, Stem rust of wheat, Brown spot of rice, Citrus canker.
- Unit 08.** Study of vegetative and reproductive stages of *Riccia*, *Anthoceros* and *Funaria* through permanent slides/photograph.
- Unit 09.** Work out and identification of *Marchantia*, *Pteris*, *Marsilea* (sporocarp).
- Unit 10.** Identification of *Lycopodium*, *Selaginella*, *Equisetum* and *Calamites* through permanent slides/specimen/photograph.
- Unit 11.** Study and identification of reproductive structure of *Cycas*, *Pinus* and *Gnetum*.
- Unit 12.** Study of fossil types. (Specimen/photograph)
- Unit 13.** Description of T.S of stem of *Lyginopteris*.
- Unit 14.** Description of leaf of *Glossopteris* and *Vertebraria*.

6CC-BT-05: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Phycology and Microbiology

Module 1: Phycology

- Unit 01.** Introduction: definition and status of algae; history of Phycology; habit, habitats and ecology; general characteristics, pigments, chloroplast and flagella ultra structure; range of thallus structures in algae, modes of reproduction and life cycle patterns in algae.
- Unit 02.** Concept of endosymbiosis (SET theory) and origin of algal chloroplast. Modern criteria of algal classification; classification systems by Fritsch (1935, 1945), and Lee (2008).
- Unit 03.** Economic importance of algae; Algal biotechnology and its application of algae: in bioremediation, agriculture (bio-fertilizers and other aspects), biotechnology (Microalgal food, Bio-diesel and Bio-ethanol production). Phycocolloids, Diatomaceous earth, Industrial applications.
- Unit 04.** Cyanophyta: general characteristics, ultra-structure; heterocyst-structure and function. Cyanobacterial genetic recombination. *Prochloron* and its evolutionary status.
- Unit 05.** Chlorophyta: general characteristics, life cycle of *Chlamydomonas*, *Volvox* and *Oedogonium*.
- Unit 06.** Charophyta: characteristic features; life cycle of *Coleochaete* and *Chara*; evolutionary, significance of charophytes in origin of land plants.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Unit 07. Xanthophyta: general characteristic; life cycle of *Vaucheria*.

Unit 08. Bacillariophyta: general characteristic; cell structure; Reproduction, different scheme of auxospore formation.

Unit 09. Phaeophyta: general characteristics; life cycle of *Ectocarpus* and *Fucus*.

Unit 10. Rhodophyta: general characteristics; life cycle patterns, sexual reproduction and post fertilization events; life cycle of *Polysiphonia*.

Module II: Microbiology

Unit 11. Virus-I: Introduction, discovery, general characteristics, structures, symmetry of capsids, replication and multiplication (general account); types of nucleic acids in viruses (Baltimore classification).

Unit 12. Virus-II: Bacteriophages structure of T-even phage and lambda phage, lytic cycle and lysogenic cycle with brief idea on molecular control of the latter, plant virus structure (TMV) and transmissions of TMV, viroids, virusoids and prions.

Unit 13. Cellular organization of Bacteria-I: basic differences between prokaryotic and eukaryotic cell, shape and size, cell membrane, cell wall – gram positive and gram negative, flagella, pili and fimbriae, capsule and slime, S-layer.

Unit 14. Cellular organization of Bacteria-II: Differences between eukaryotic and prokaryotic chromosome organization, bacterial genome- nucleoid, plasmid and episome, types of plasmids-role and importance, ribosome, endospore, inclusion bodies.

Unit 15. Bacterial Systematics: Eubacteria and Archaebacteria – brief account of six kingdom and three domain classification, Bergey's manual, difference between Archaea and Bacteria.

Unit 16. Bacterial growth and control- binary fission and population growth, phase of bacterial growth, generation time, growth conditions temperature, oxygen, water activity, pressure and pH, broad outline of control mechanisms uses of heat, chemicals and radiation, antibiotics-definition and groups with examples.

Unit 17. Genetic Recombination in Bacteria-I: conjugation, role of F plasmid, F⁺, F' and Hfr donor, role of plasmid.

Unit 18. Genetic Recombination in Bacteria-II: transformation and transduction, historical account of transformation, competence, uptake of DNA and expression, induced transformation, transduction generalized and specialized.

Unit 19. Microbial Ecology: ecological importance of microbes, bio-geochemical cycles- N₂, P and S cycle; plant-microbe interaction -tumorogenesis, and nitrogen fixation, natural microflora of human body and their importance in sustenance of human body.

Unit 20. Applied Microbiology: Role of microbes in pharmaceutical industry, food industry and research.

6CC-BT-06: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Mycology and Phytopathology

Module-I: Mycology

Unit 01. Introduction of true Fungi: General characteristics. affinities with plants and animals,

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

thallus organization, structure and composition of cell wall, nutrition, reproduction, homothallic and heterothallic nature. Classification of fungi (Ainsworth, 1973) up to sub division with diagnostic characters and examples, economic importance of fungi.

- Unit 02.** Chytridiomycota and Zygomycota: general characteristics, habitat, economic importance, thallus organization, reproduction, life cycle (based on word diagram).
- Unit 03.** Ascomycota: general characters, habitat, economic importance, thallus organization, reproduction types of fruit bodies. Classification and life cycle.
- Unit 04.** Basidiomycota: general characters, economic importance, thallus organization, reproduction, types of fruit bodies, classification and life cycle. Cultivation technique of mushroom (in brief).
- Unit 05.** Deuteromycota: general characters, economic importance, thallus organization, reproduction, heterokaryosis and parasexuality, classification.
- Unit 06.** Myxomycota: present status, habitat, classification, vegetative body, fructification.
- Unit 07.** Oomycota: present status, habitat, thallus organization, life cycle of *Phytophthora*.
- Unit 08.** Life cycle of *Rhizopus* and *Penicillium*.
- Unit 09.** Life cycle of *Agaricus* and *Helminthosporium*.
- Unit 10.** Lichen: habitat, types, vegetative and reproductive structures, specialized structures, economic and ecological importance. Mycorrhiza: types and their characteristics, economic importance.

Module-II: Phytopathology

- Unit 11.** Some relevant terms and their definitions.
- Unit 12.** General symptoms of plant diseases.
- Unit 13.** Spread of disease and physiological effects of pathogen.
- Unit 14.** Host-pathogen interaction: Preformed and induced defense mechanisms, SAR, ISR. Vertical and Horizontal resistance. Concept of R gene and *avr* interaction. Effectors-recognition and evasion, concept of coevolution.
- Unit 15.** Management of plant diseases: IPM, chemical and biological control
- Unit 16.** Some common plant diseases of economic importance with special reference to Indian crops: Symptoms, causal organisms
- Unit 17.** Concept of plant disease epidemics, examples of plant diseases having socioeconomic impact in Indian context.

6CC-BT-07: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Archegoniate & Paleobotany

- Unit 01.** Bryophyta: Introduction, general characteristics. Modern classification of Bryophytes (Crandal-Stotler and Stotler 2009) up to class.
- Unit 02.** General features, life cycle of *Riccia*, *Marchantia*, *Porella*, *Anthoceros* and *Funaria* (developmental stages not included).
- Unit 03.** Ecological and economic importance of Bryophytes with special reference to *Sphagnum*.
- Unit 04.** Pteridophytes: general characteristics of Pteridophytes. Pteridophyte Phylogeny Group (PPG-I: 2016) and Classification of Pteridophytes up to class (Sporne, 1975).

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 05.** General features, life cycle of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum* and *Pteris* (developmental stages not included).
- Unit 06.** General characters of *Cooksonia*, *Rhynia* and *Lepidodendron*.
- Unit 07.** Apogamy, apospory, heterospory and seed habit, origin and evolution of Pteridophytes. Telome concept and its significance. Stelar evolution, economic importance of Pteridophytes.
- Unit 08.** Characteristics of Gymnosperms and their classification.
- Unit 09.** General features, life cycle of *Cycas*, *Pinus* and *Gnetum* (developmental stages not included).
- Unit 10.** General features of *Lyginopteris*, *Williamsonia* and *Cordaites*.
- Unit 11.** Ecological and Economic importance of Gymnosperms.
- Unit 12.** Plant Fossil: concept and types, trace fossil, chemical fossil, index fossil, different modes of preservation (Schopf, 1975), conditions favouring fossilization, nomenclature and reconstruction, importance of fossil study, method of radiometric dating
- Unit 13.** Geological time scale: dominant plant groups through ages.
- Unit 14.** Indian Gondwana System – Threefold division with major megafossil assemblages.

7CC-BT-08: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Anatomy, Economic Botany; Morphology, Plant Systematics (Practical)

Module-I: Anatomy

- Unit 01.** Identification of anatomical structures with reasons (from permanent slide); parenchyma and collenchyma, sclerenchyma, sclereids, tracheids, trachea and sieve tube.
- Unit 02.** Identification of anatomical structures with reasons (from permanent slide); different types of vascular bundles.
- Unit 03.** Identification of anatomical structures with reasons (from permanent slide); different types of stomata.
- Unit 04.** Identification of anatomical structures with reasons (from permanent slide); trichomes and lenticel.
- Unit 05.** Study of secondary growth (permanent slides should be prepared by the students): *Boerhavia* and *Bignonia* stem, *Dracaena* stem and *Tinospora* root.

Module-II: Economic Botany

- Unit 06.** Beverages: Tea (plant specimen, tea leaves).
- Unit 07.** Essential oil-yielding plants: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/ photographs).
- Unit 08.** Rubber: specimen, photograph/model of tapping, samples of rubber products.
- Unit 09.** Drug-yielding plants: Specimens of *Digitalis*, *Papaver* and *Cannabis*.

Module-III: Morphology

- Unit 10.** Study of cohesion and adhesion of stamen and carpel.
- Unit 11.** Types of inflorescences, placentation.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Module-IV: Plant Systematics

- Unit 12.** Taxonomic study of angiospermic plants; *Brassica* spp., *Sida* spp., *Senna* spp, *Coccinia grandis*.
- Unit 13.** Taxonomic study of angiospermic plants: *Solanum* spp., *Leonurus sibiricus*, *Leucus* spp, *Oldenlandia* spp, *Ixora* spp.
- Unit 14.** Preparation and submission of ten herbarium specimens of different taxa which are commonly available.

7CC-BT-09: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Plant Physiology; Reproductive Biology of Angiosperms, Cell Biology & Genetics (Practical)

Module-I: Biomolecules and Plant Metabolism

- Unit 01.** Detection of organic acids: Citric, Tartaric, Oxalic and Malic.
- Unit 02.** Detection of Carbohydrate from plant samples. (Molish Test)
- Unit 03.** Detection of protein from plant samples. (Biuret test)
- Unit 04.** Detection of Ca, Mg, Fe & S from plant sample.
- Unit 05.** Estimation of catalase activity from plant materials by colorimetric method and aminonitrogen by titrimetric method.
- Unit 06.** To compare the rate of respiration in different parts of a plant.

Module-II: Plant Physiology

- Unit 07.** Preparation of solutions (percent and Molar). Demonstration of osmotic pressure by plasmolytic method using *Rhoeo* leaf.
- Unit 08.** Determination of rate of transpiration per unit area by weighing method.
- Unit 09.** Imbibition of water by dry seeds (starchy, proteinaceous and fatty seeds).
- Unit 10.** Determination of (%) seed viability by TTC (Triphenyl Tetrazolium Chloride) test.
- Unit 11.** Effect of CO₂ on photosynthesis using bicarbonate solutions.
- Unit 12.** Determination of Q₁₀ for imbibition of water using dry gram seeds.

Module-III: Reproductive Biology

- Unit 13.** Pollen grains viability test Study permanent slide showing ornamentation types.
- Unit 14.** Study of pollinia from permanent slides.

Module-IV: Cell Biology

- Unit 15.** Study of mitotic chromosome: Metaphase chromosome preparation (Pre-treatment, Fixation, Staining).
- Unit 16.** Temporary squash preparation of *Allium cepa* & *Aloe* root tips.
- Unit 17.** Determination of mitotic index and frequency of different mitotic stages in prefixed root

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

tips of *Allium cepa*.

Unit 18. Identification of different mitotic stages from permanent slides.

Unit 19. Temporary smear preparation from *Allium* & *Rhoeo* flower buds for study of meiotic chromosome.

Unit 20. Identification of different meiotic stages from permanent slides.

Module-V: Genetics

Unit 21. Determination of mean, standard deviation and standard error from samples.

Unit 22. Determination of Goodness of fit in normal and modified monohybrid & dihybrid ratios.

7CC-BT-10: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Anatomy; Economic Botany

Module- I: Plant Anatomy

Unit 01. Plant cell wall.

Unit 02. Tissues types and functions.

Unit 03. Structures of root apex and shoot apex.

Unit 04. Mechanical tissues and their principles of distribution.

Unit 05. Types of stomata.

Unit 06. Stellar types and evolution.

Unit 07. Nodal anatomy.

Unit 08. Cambium-primary and secondary structures, nature and functions.

Unit 09. Secondary growth of stem and root.

Unit 10. Anomalous secondary growth (stem of *Bignonia*, *Boerhaavia*, *Dracaena* and root of *Tinospora*).

Module-II: Economic Botany

Unit 11. Concept of Centers of Origin, their importance with reference to Vavilov's work. Economic plants – classification and uses.

Unit 12. Scientific name, family, parts used and uses of Maize, Mung, Ginger, Sugar cane, Mustard.

Unit 13. Scientific name, family, parts used and uses of Lemon grass, coconut, Sal, Teak, Cotton.

Unit 14. Cultivation of paddy, wheat and jute.

Unit 15. Cultivation of Tea and Coffee and their processing.

Unit 16. Pharmacognosy- definition, objectives and importance. Scientific name, family, active principles and uses of the following medicinal plants: Ipecac, Kalmegh, Neem and Vasaka.

Netaji Subhas Open University
Four-year Undergraduate program in Botany
Syllabus

7CC-BT-11: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Morphology; Plant Systematics

Module- I: Morphology

- Unit 01.** Inflorescence – different types with examples.
- Unit 02.** Flowers – types, aestivation, cohesion and adhesion of stamens.
- Unit 03.** Placentation, different types of ovules.
- Unit 04.** Fruits – types with examples.
- Unit 05.** Seeds – types with examples.

Module-II: Plant Systematics

- Unit 06.** Taxonomy, Systematics, Classification, Identification and Nomenclature – terms and definitions only. Phases of taxonomy; Types of Classifications– Artificial, Natural and Phylogenetic, definitions and examples.
- Unit 07.** Nomenclature – elementary knowledge of recent ICN (ICBN) including important rules. Effective and Valid Publications. Rules of priority Author citation, Ranks and Names. Type concept.
- Unit 08.** Broad features of the systems of classifications of Linnaeus (artificial). Bentham and Hooker (natural). Cronquist (phylogenetic). APG System of flowering plant, Classifications with special reference to APG-IV (2016).
- Unit 09.** Herbaria and Botanical gardens – importance and functions, five each important herbaria in India and World. Collection of specimens, preparation of herbarium sheets, their preservation and maintenance of Herbarium; Virtual Herbarium; E-Flora.
- Unit 10.** Diagnostic features and systematic position (according to Bentham and Hooker, and Cronquist's systems) of the following families: Magnoliaceae, Nymphaeaceae, Malvaceae, Cucurbitaceae, Brassicaceae (Cruciferae).
- Unit 11.** Diagnostic features and systematic position (according to Bentham and Hooker, and Cronquist's systems) of the following families: Fabaceae (Leguminosae), Euphorbiaceae, Apiaceae (Umbelliferae).
- Unit 12.** Diagnostic features and systematic position (according to Bentham and Hooker, and Cronquist's systems) of the following families of Dicots: Solanaceae, Lamiaceae (Labiatae), Scrophulariaceae, Rubiaceae and Asteraceae (Compositae).
- Unit 13.** Diagnostic features and systematic position (according to Bentham and Hooker, and Cronquist's systems) of the following families of Monocots: Alismataceae, Arecaceae (Palmae), Poaceae (Gramineae).
- Unit 14.** Alpha taxonomy and Omega taxonomy. Taxonomic evidences from palynology, cytology, phytochemistry and molecular data.
- Unit 15.** Character and character states, OTU, Phenograms, Numerical Taxonomy, Cladistics and Cladogram.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

7CC-BT-12: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Physiology; Reproductive Biology of Angiosperms

Module-I: Plant physiology

- Unit 01.** Cell physiology: Introduction, cell membrane, water potential - its components and symbols, imbibition, diffusion, osmosis, plasmolysis, osmotic relation of a plant cell.
- Unit 02.** Water relation in plants: Introduction, molecular structure and physical properties of water, types of water in the soil, availability and usefulness of water to the plants, absorption of water.
- Unit 03.** Ascent of sap: Basic concepts, pathway of transportation of water.
- Unit 04.** Transpiration: definition, types and sites of transpiration, mechanism of stomatal transpiration, factors affecting transpiration, anti-transpirants, guttation.
- Unit 05.** Mineral nutrition of plants: Introduction, essential and non-essential elements, criteria of essentiality of elements, general and specific roles of macro- and micro-elements in plants, deficiency symptoms.
- Unit 06.** Translocation of solutes: definition, translocation of organic materials, direction and mechanism of phloem transport, translocation of inorganic materials, Phloem loading and unloading
- Unit 07.** Growth Physiology: definition of growth, differentiation and development, sites of plant growth, phases of growth, factors affecting growth, measurement of growth.
- Unit 08.** Plant growth regulation: Concept of plant growth regulators and phytohormones, growth promoters, retardants and inhibitors; natural, synthetic and postulated hormones, physiological roles of Auxins, Gibberellins, Cytokinins, Ethylene and Absciscic acid. Biosynthesis and bioassay of IAA and Gibberellins. Brief idea on BRS, Systemin.
- Unit 09.** Photosynthesis: Light reaction, concept of photosystem I and II, reaction Centre, antenna molecule; electron, transport and mechanism of ATP synthesis, Calvin cycle, photosynthetic efficiency, HSK and CAM pathway, bacterial photosynthesis.
- Unit 10.** Respiration: types of Respiration, Glycolysis, Krebs cycle, ETS and Oxidative Phosphorylation, Pentose Phosphate Pathway, R.Q.
- Unit 11.** Photorespiration: definition, mechanism, compartmentalization reactions, differences between Respiration and Photorespiration significance.
- Unit 12.** Nitrogen fixation: sources of nitrogen, biological nitrogen fixation- symbiotic and non-symbiotic, mechanism, nodulins, basic concept of *nif* and *nod* genes.
- Unit 13.** Physiology of flowering: Photoperiodism, critical day length, classification of flowering plants (SDP, LDP, DNP, SLDP, and LSDP), site of perception of photoperiodic stimulus, vernalization and de-vernalization, role of phytochrome in flowering.
- Unit 14.** Seed physiology: definition of propagules and seeds, germination and dormancy of seeds, morphological and biochemical changes during seed germination, types, causes of methods of breaking seed dormancy.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Module-II: Reproductive Biology of Angiosperms

- Unit 15.** Introduction: History (contributions of J. Heslop-Harrison, P. Maheshwari, B.M. Johri) and scope.
- Unit 16.** Pollination– definition, types, contrivances, agents, advantages and disadvantages.
- Unit 17.** Development of male and female gametophytes.
- Unit 18.** Fertilization, types with examples.
- Unit 19.** Development of endosperms (three types); apomixis, apospory and apogamy, polyembryony.
- Unit 20.** Self-Incompatibility: Basic concept (interspecific; intraspecific, heteromorphic); Cybrids; *in-vitro* fertilization.
- Unit 21.** Palynology; pollen types, and surface structure, NPC system of classification.

7CC-BT-13: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Biomolecules and Plant Metabolism

Module-I: Biomolecules

- Unit 01.** Carbohydrates: Nomenclature and classification; monosaccharides, disaccharides; oligosaccharides and polysaccharides.
- Unit 02.** Lipids: Definition and major classes of storage and structural lipids; fatty acids- structure and function; essential fatty acids.
- Unit 03.** Trilglycerols structure, function and properties; phosphoglycerates.
- Unit 04.** Proteins: structure of amino acids; levels of protein structure-primary, secondary, tertiary and quaternary.
- Unit 05.** Protein denaturation and biological roles of proteins.
- Unit 06.** Nucleic acids: structure of nitrogenous bases; structure and functions of nucleotides; types of nucleic acids.
- Unit 07.** Structure of A, B and Z-types of DNA; Types of RNA; tRNA, r-RNA, m-RNA, structure of t-RNA (Clover leaf model).
- Unit 08.** Bioenergetics: Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reaction, redox reaction.
- Unit 09.** ATP; structure and its role as an energy currency molecule.
- Unit 10.** Plant pigments: Introduction, plastidial and non-plastidial pigments.
- Unit 11.** Absorption of light energy by plant pigments, chemistry of chlorophylls and carotenoids.

Module-II: Plant Metabolism

- Unit 12.** Basic biochemistry: Elements and Chemical bonds, Role of Water, pH, buffer solutions in plant biology.
- Unit 13.** **Enzyme** Structure and properties: holoenzyme, apoenzyme, cofactors, coenzyme and prosthetic groups. Classification of enzymes, according to IUB active site of enzyme,

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

specification, mechanism of action (activation energy, induced – fit and acid base theory).

Unit 14. Enzyme kinetics, Michaelis-Menten equation, different types of enzyme inhibition and their effect on V_{max} and K_m , factors affecting enzyme activity. allosteric enzyme.

7CC-BT-14: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Cell Biology

Unit 01. Microscopy: different types of microscopy Light, Phase contrast, Fluorescence and Electron microscopy; Confocal microscopy.

Unit 02. Eukaryotic Cell: Organization and functional structures and chemical components.

Unit 03. Nuclear organization: ultrastructure of nuclear envelope, structure and functions of Nucleus.

Unit 04. Structure and functions of peroxisome and glyoxisome.

Unit 05. Structure and functions of lysosomes.

Unit 06. Structures and functions of mitochondria.

Unit 07. Structures and functions of chloroplasts.

Unit 08. Endomembrane system, general idea; endoplasmic reticulum: structure and function.

Unit 09. Golgi apparatus: organization and function.

Unit 10. Cell cycle and its control.

Unit 11. Cell division: Mitosis and Meiosis: Detail accounts of phases and events; Their significance.

Unit 12. Structure and functions of Ribosome.

Unit 13. Signal transduction: general idea of signal transductions. Signal transduction pathway, secondary messengers.

Unit 14. Microtubule; structural components and functional assembly.

7CC-BT-15: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Genetics

Unit 01. Mendelian genetics: Mendel's laws and chromosome theory of inheritance; complete dominance, incomplete dominance and co-dominance.

Unit 02. Gene interactions; different types of gene interactions- multiple alleles; lethal alleles; allelic complementation Test and Complementary Gene Action.

Unit 03. Epistasis – different types; Modifier and Suppressor Genes; Pleiotropy; Penetrance and Expressivity.

Unit 04. Environment and Gene Expression; Polygenic Inheritance.

Unit 05. Linkage, Crossing-over and Chromosome mapping: Linkage types; Synteny; Linkage Groups and Linkage Maps; Crossing-over and its cytological proof (in Maize); Recombination Frequency; Three-point test cross; Interference and Coincidence;

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

numerical based on Gene mapping;

Unit 06. Sex-chromosomes and Sex-linkage.

Unit 07. Extra-Nuclear Inheritance: Maternal, Paternal and Bi-parental inheritance; Chloroplast mutation –variegation in *Mirabilis jalapa*; Mitochondrial mutation in yeast; Maternal Effects– shell-coiling in snail; Infective heredity with examples.

Unit 08. Eukaryotic Chromosome – structure and organization: Chromosome Number, Morphology, Nomenclature and Organization; Polytene chromosomes;

Unit 09. Euchromatin, Heterochromatin – Constitutive and Facultative, Chromosome banding, In-situ Hybridization–FISH; Chromosome painting.

Unit 10. Variation in Chromosome Number and Structure: Polyploidy and Aneuploidy; Deletion, Duplication, Inversion and Translocation; Position Effect.

Unit 11. Gene Mutation: Types and molecular basis of mutations, mutagens physical and chemical with modes of induction of examples of cited examples; detection of mutations CIB method.

Unit 12. DNA damage repair Pathways- photoreactivation, mismatch repair, excision repair, SOS repair.

Unit 13. Modern Concept of Gene and Genetic Code: One gene- One Polypeptide hypothesis; Central Dogma; Properties of genetic code and its decipherence.

Unit 14. Population and Evolutionary Genetics: Allele and Genotype frequencies; Hardy–Weinberg Law. Role of Natural Selection, Migration, Mutation and Genetic Drift; Genetic variation and Speciation. Methods for detection of genetic variations in populations.

8CC-BT-16: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Molecular Biology

Unit 01. DNA – Genetic Material and Structure: DNA as genetic material – proof, types of DNA and genetic material; structural organization of DNA (overview) in Viruses, Prokaryotes and Eukaryotes.

Unit 02. DNA packaging in eukaryotes: Chromatin structure and nucleosomes; chromatin remodelling.

Unit 03. Sequence complexity of DNA. Reassociation kinetics -- Denaturation, Renaturation, Melting Temperature (T_m) and Cot Curves; hyperchromic effect; topology--functional deformations of DNA.

Unit 04. Repetitive DNA -- satellite DNA; centromeric DNA sequences; different types of repetitive DNA; VNTR and STRs; SINEs and LINEs; c-value paradox.

Unit 05. DNA replication: General principles – bi-directional, semi-conservative and semi-discontinuous; RNA priming; models of DNA replication; multiple eukaryotic DNA polymerases involved in DNA replication; replication through chromatin.

Unit 06. Telomeres in chromosome stability. End-replication problem in eukaryotic chromosomes; telomeres and mechanism of telomerase function; telomeres in disease, ageing and

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

cancer.

- Unit 07.** DNA recombination. Homologous recombination (different models); site-specific recombination and transposition.
- Unit 08.** Transposable Elements. Transposable elements in Prokaryotes and Eukaryotes, their classification and properties.
- Unit 09.** Plasmids – structure and properties; plasmid pBR 322 – salient features.
- Unit 10.** Transcription and its regulation. The Central Dogma; transcription; reverse transcription and translation; transcription factors and machinery; formation of initiation complex, transcription activator and repressor; RNA polymerases, capping, elongation, and termination. Levels of gene regulation; examples of positive and negative regulatory mechanisms. Differences in transcription between bacteria and eukaryotes.
- Unit 11.** Eukaryotic RNA processing and its modification. RNA processing: caps and tails; split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing; alternative splicing; RNA editing and mRNA transport. RNA regulation, basic concepts.
- Unit 12.** Gene Expression and its Regulation. Eukaryotic RNA – split genes and splicing Mechanism; mRNA processing; RNA editing and mRNA transport. Translation – initiation, elongation and termination of polypeptides; polyribosomes; inhibitors of protein synthesis; post-translational modification of proteins.
- Unit 13.** Restriction Endonuclease and Recombinant DNA Technology. Restriction enzymes – nomenclature, types and functions with examples.
- Unit 14.** Gene Cloning – basic steps; cloning vectors – properties and types; shuttle vector and expression vector; reporter genes; cloned genes and recombinant proteins; ethical and legal considerations.
- Unit 15.** Genomic Library, RFLP. Construction of genomic, chromosome and cDNA libraries; screening of DNA library; genomics, genome sequences and their annotation; single nucleotide polymorphism and haplotypes. Future directions in Genomics; RFLPs and their uses.

8CC-BT-17: (Credit-4 / Marks-100; TEE-100; ASSGN-0)

Plant Biotechnology & Molecular Biology (Practical)

Module-I: Plant Biotechnology

- Unit 01.** Study of the different components of a model tissue culture laboratory.
- Unit 02.** Aseptic (sterilization) techniques used in plant tissue culture.
- Unit 03.** Basic steps in preparing sterile explants for culture.
- Unit 04.** Preparation of plant tissue culture medium (MS).
- Unit 05.** Observation and characterization of callus & differentiated tissues – through photographs / live specimen and comments on the morphogenetic status.
- Unit 06.** Study of anther, embryo, endosperm and cell-suspension culture through photographs and comment on specific techniques.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Unit 07. Study of different Micropropagation techniques through photographs.

Unit 08. Study of different stages of somatic embryogenesis and artificial seeds production through photographs.

Unit 09. Study of genetic transformation techniques (Bt Cotton, Golden rice, Flavr-Savr) through photographs.

Module-II: Molecular Biology

Unit 10. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery *et al*, Griffith's, Hershey and Chase's, Fraenkel and Conrat's experiments).

Unit 11. Study of restriction endonuclease mediated DNA cuts through RFLP gel photographs..

Unit 12. Study of different types of cloning vectors through photographs.

Unit 13. Study of structural integration of polymerase complex through photographs.

Unit 14. Study of different types of biological database and accessing their functionality (Gene Bank, Protein Data Bank (PDB), UniProt, KEGG, OMIM). Study of specific database (model organism; Arabidopsis, Rice, Wheat, Maize).

8CC-BT-18: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Biotechnology

Unit 01. Historical perspectives; cellular totipotency; different in vitro culture techniques.

Unit 02. Management of contamination-- initial, latent and introduced; surface sterilization of plant materials.

Unit 03. Media components and preparation (a brief account): inorganic salts, PGRs, vitamins, carbohydrates, hexitols, gelling agents, amino acids, antibiotics, natural complexes and media pH.

Unit 04. Culture media – different types, general idea of composition and their basic differences; inoculation, incubation and acclimatization.

Unit 05. Callus culture; Callus induction, initiation and formation and applications.

Unit 06. Regeneration and morphogenesis; organogenesis, embryogenesis, cell suspension culture -basic principles and importance.

Unit 07. Somatic embryogenesis- explant preparation and procedure; differences with zygotic embryogenesis; artificial seeds; embryo culture and their applications.

Unit 08. Haploid plants from anther or microspore culture; application of haploids and double haploids and applications.

Unit 09. Meristem culture for virus-free plants.

Unit 10. Protoplast isolation, culture and its applications. Somatic hybridization (interspecies); Somaclonal-variation and their applications.

Unit 11. Micropropagation—Stages of common techniques and applications.

Unit 12. Transgenic plants and their applications. *Agrobacterium*-mediated genetic transformation.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Genetic organization of Ti plasmids, functions encoded by integrated T- DNA and the molecular mechanism of transformation. Electroporation, particle gun technologies and microinjection. Issues on biosafety and bioethics.

Unit 13. Tissue culture in conservation of endangered plants - a general account. Cryopreservation and germplasm conservation.

Unit 14. Molecular markers -Idea about dominant and co-dominant markers.(RFLPs, SSRs, SNPs and their uses in plants and microbes. DNA finger printing in crop improvement programme. Genome editing and RNAi technologies in plants -- a brief introduction and difference with GMOs.

8CC-BT-19: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Analytical Techniques in Plant Sciences

Unit 01. Laboratory handling and biosafety practices. Good and safe general laboratory practices and biosafety measures (first-aid in cases of burn and acid-spill injury); knowledge of safety symbols, lab-safety equipments (fire extinguishers, fume hood and safety glasses); categories of laboratory chemicals, their handling and maintenance (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade; Expiry date; Precautions for use); Disinfectants and Sterilizing agents; Biocontainment; Disposal of hazardous chemicals, biological and radioactive waste; Laboratory waste management.

Unit 02. Laboratory equipment -- their use and maintenance. Weighing balance (top-loading & analytical), pH meter (their calibration and use), magnetic stirrer, pipettes & micropipettes, autoclave, BOD incubator, incubator shaker, laminar airflow, micrometer, haemocytometer, spectrophotometer, thermal cycler, UV transilluminator, gel documentation system, agarose gel electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter and lux meter.

Unit 03. Measurements and calculations. Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions.

Unit 04. Solutions and Buffers. Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acids and bases, buffers - phosphate, Tris-acetate, Tris- Cl and Citrate buffer.

Unit 05. Microscopy, sample and slide preparation. Principles of microscopy; Microscopes -- Dissecting, Compound, Transmission and Scanning Electron microscopes -their sample preparation and staining; introduction to other types of microscopy -- Confocal, Fluorescence; fluorochromes and their use; applications of fluorescence microscopy in chromosome banding, FISH and chromosome painting; Flow cytometry (FACS).

Unit 06. Cell fractionation- Centrifugation: Differential and density gradient centrifugation, sucrose, CsCl₂ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 07. Characterization of proteins and nucleic acids - Broad overview of the steps involved.

Unit 08. Spectrophotometry -- Principle and its application in biological research. UV-Visible light Spectroscopy. Atomic absorption and Flame emission spectroscopic techniques; Mass spectrometry.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 09.** Chromatography-Principle and its application in biological research. Paper chromatography; Column chromatography; TLC; GLC; HPLC; Ion- exchange chromatography; Molecular sieve chromatography; Affinity chromatography.
- Unit 10.** Electrophoresis--Broad principle; Acrylamide Gel Electrophoresis (AGE), Polyacrylamide Gel Electrophoresis (PAGE), Sodium Dodecyl Sulphate-Polyacrylamide Gel Electrophoresis (SDS-PAGE); Immuno-electrophoresis, Iso-electrofocussing & Capillary Electrophoresis; ELISA.
- Unit 11.** Other analytical techniques. X-ray diffraction analysis and their applications; X-ray crystallography; electrophoretic mobility shift assay (EMSA) for characterizing protein-nucleic acid interactions.
- Unit 12.** Specialized techniques for analysis of proteins. A broad overview and applications of infrared (IR), near infrared (NIR), Fourier-Transform infrared (FTIR) and Raman spectroscopy; nuclear magnetic resonance (NMR) & solid-state NMR (ss-NMR); circular dichroism (CD); Western blotting.
- Unit 13.** Specialized techniques for analysis of nucleic acids. Polymerase Chain Reaction (PCR), reverse transcriptase PCR (RT-PCR) and quantitative RT-PCR (qRT-PCR); Southern blot and Northern blot; chromatin immunoprecipitation (ChIP); DNA and RNA sequencing (RNA-Seq) -- next generation sequencing technologies (NGS)- Illumina-, Nanopore-, and PacBio, brief idea and about possible its clinical applications.
- Unit 14.** Biostatistics. Statistics and statistic; population, samples, parameters; sampling methods - merits and demerits; technical and biological replicates; presentation of data -- tabular and graphical; measures of central tendency: Arithmetic mean, mode, median; difference between sample mean and population mean. Measures of dispersion: range, mean deviation, coefficient of variation, variance, standard deviation and standard error of mean; chi-square test for goodness of fit. Concept of Analysis of Molecular Variance (AMOVA).

8CC-BT-20: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Natural Resource Management

- Unit 01. Natural resources:** Definition and types.
- Unit 02. Sustainable utilization:** Concept, approaches (economic, ecological and socio-cultural).
- Unit 03. Land:** Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management, green belt development.
- Unit 04. Water:** Fresh water (rivers, lakes, groundwater, aquifers, watershed).
- Unit 05.** Marine and Estuarine resources, their importance and conservation, Names of major estuary systems of India, restoration of mangrove ecosystems.
- Unit 06.** Wetlands; wetlands of India and West Bengal, importance, threats, management strategies, importance of Ramsar site.
- Unit 07.** Biological Resources and conservations: Biodiversity: definition and types; significance; threats; management strategies;

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 08.** Bioprospecting and Biopiracy; definition, examples from agricultural and pharmaceuticals; IPR; CBD; brief idea of National Biodiversity Action Plan.
- Unit 09. Forests:** Definition, types, outline idea of farm forestry, social forestry, agroforestry; significance of forest cover (with special reference to India); cause of depletion / threats; conservation and management strategies.
- Unit 10.** Major and minor forest products; non-wood forest produce (fibers, oils, seeds, dyes, gums, resins, drugs, spices, animals, minerals).
- Unit 11.** Energy: Renewable and non-renewable energy sources; advantages and disadvantages of renewable and non-renewable energy sources, biodiesel and bioethanol.
- Unit 12.** National Natural Resources Management System (NNRMS, 2022): Prime objectives and major achievements.
- Unit 13.** Community Based Natural Resource Management (CBNRM): Concept, strengths and weakness; national biodiversity authority (NBA), people biodiversity region (PBR) and sacred groves.
- Unit 14.** Contemporary practices in resource management: EIA, GIS, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

8CC-BT-21: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Ethnobotany & Pharmacognosy

- Unit 01.** Ethnobotany—Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science,
- Unit 02.** The relevance of ethnobotany study in the present context; major and minor ethnic groups including tribals of India and their life styles. Plants used by the tribals:-a) food plants, b) intoxicants and beverages, c) resins and oils, and d) miscellaneous uses.
- Unit 03.** Methodology of Ethnobotanical studies – a) Field work, b) Herbarium, c) Ancient Literature, d) Archaeological findings, e) Sacred places.
- Unit 04.** Role of Ethnobotany in modern medicine - Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) a) *Azadirachta indica*, b) *Ocimum sanctum*, c) *Vitex negundo*, d) *Gloriosa superba*, e) *Tribulus terrestris*, f) *Pongamia pinnata*, g) *Senna auriculata*, h) *Indigofera tinctoria*.
- Unit 05.** Role of ethnobotany in modern medicine with special example to *Rauvolfia serpentina*, *Trichopus zeylanicus*, *Artemisia indica* and *Withania somnifera*. Role of ethnic groups in conservation of plant genetic resources. Role of CCRAS.
- Unit 06.** Ethnobotany and legal aspects- Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Indigenous Traditional Knowledge, Traditional Knowledge Digital Library (TKDL), Access and Benefit Sharing (ABS).
- Unit 07.** Pharmacognosy- General account: Pharmacognosy and its importance in modern medicine, Crude drugs, Classification of drugs- chemical and pharmacological, Drug

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

evaluation– organoleptic, microscopic, chemical, physical and biological.

- Unit 08.** Systematic position and medicinal uses of the following herbs in curing various ailments: Tulsi (Krishna tulsi: *Ocimum tenuiflorum*, Babui/dulal tulsi: *O. basilicum*, Radha tulsi: *O. sanctum*), Ginger (*Zingiber officinale*), Fenugreek (Methi: *Trigonella foenum-graecum*), Indian Goose berry (Amlaki: *Phyllanthus emblica*) and Ashoka (Ashoka: *Saraca asoca*).
- Unit 09.** Secondary metabolism, differences between primary and secondary metabolism, broad categories of secondary metabolites; significance.
- Unit 10.** Phytochemistry-active principles and methods of their testing - identification and utilization of the medicinal herbs: *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).
- Unit 11.** Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).
- Unit 12.** Ethnobotany and Folk medicine: concept of folk medicine, folk taxonomy, folk drug dosimetry, History of Indian folk medicine.
- Unit 13.** Role of Botanical Survey of India in Indian Ethnobotany: History of Indian Ethnobotany in respect to Botanical Survey of India.
- Unit 14.** Literature sources and database in ethnobotany.

8CC-BT-22: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Breeding & Biostatistics

- Unit 01.** Plant Breeding: Principles and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements of plant breeding in India.
- Unit 02.** Centres of origin and domestication of cultivated plants. Plant genetic resources.
- Unit 03.** Methods of crop improvement. Plant introduction and acclimatization; Selection methods for self pollinated, cross pollinated and vegetatively propagated plants -- mass, pure-line & clonal selection and their importance. Hybridization-- for self, cross and vegetatively propagated plants; procedure, advantages and limitations.
- Unit 04.** Quantitative inheritance: Concept, mechanism, examples of inheritance of kernel colour in wheat, skin colour in human beings. Monogenic and polygenic Inheritance.
- Unit 05.** Inbreeding depression and heterosis: genetic basis of inbreeding depression and heterosis; applications.
- Unit 06.** Mutation breeding; Role of polyploidy and distant hybridization in crop improvement.
- Unit 07.** Role of biotechnology in crop improvement.
- Unit 08.** Marker-assisted breeding (MAS) -- a brief overview.
- Unit 09.** Biostatistics: definition; statistics & statistic; concept of population, sample and parameter; variables-different types.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 10.** Data-primary and secondary; data types and their collection. Random sampling. Exploratory data analysis, tabulation (frequency distribution table) and presentation of data.
- Unit 11.** Descriptive statistics. Measures of central tendency-Arithmetic mean, Median and Mode. Measures of dispersion-Range, Variance, Mean deviation, Standard deviation, Coefficient of variation. Standard Error of mean; Confidence interval for mean values; Central Limit theorem.
- Unit 12.** Inferential statistics. Statistical inference. Probability-basic rules; laws of probability. Normal, Binomial and Poisson distribution. Assessing normality.
- Unit 13.** Hypothesis testing; Student's *t*-test; relation between *t*-test and confidence interval; the P-value; Type I & Type II errors; one-tailed *t*-test; Chi-Square goodness of fit test. Analysis of variance--one-way ANOVA; *F*-test.
- Unit 14.** Linear regression and correlation. Product moment correlation coefficient; correlation & causation. Linear regression analysis, the fitted regression line & prediction. Correlation and regression compared and their interpretation.
- Unit 15.** Computer applications in biostatistics - MS Excel and R.

8CC-BT-23: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Environmental Biotechnology

- Unit 01. Environment-constituents and issues.** Global environmental problems due to anthropogenic activities, Concept of Anthropocene. Ozone depletion & UV-B, global warming, energy crisis, acid rain, oil spills, decline and loss of species -- their impact and biotechnological approaches for management.
- Unit 02. Environmental pollution.** Definition and types. Primary and secondary pollutants, degradable and non-degradable, point and nonpoint sources of pollution. Fate of pollutants in the environment. and Bioconcentration, bio/geomagnification.
- Unit 03. Air pollution:** Definition, sources of air pollution, their effects on flora, fauna, humans and material objects. Conventional fuels (firewood, coal, gas, animal oils) and their environmental impact. Indoor pollution, automobile pollution, gas-phase VOCs. Brief account of the London smog, Bhopal gas tragedy, Visakhapatnam gas leak and endosulphan tragedy in Karnataka.
- Unit 04. Water pollution:** Definition, sources of water pollution and their effects on flora, fauna, humans and materials. *Surface water pollution* – Dissolved oxygen, biochemical oxygen demand and chemical oxygen demand. Agriculture runoff and Eutrophication. Heavy metal pollution – Minamata Bay episode. *Ground water pollution* – fluoride, nitrate & arsenic pollution.
- Unit 05. Soil pollution:** Agrochemical sources -- insecticides, herbicides, fungicides; pollutants from urban sources, thermal power stations, transport activities. Effects of pollution on soil health and productivity.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 06. Xenobiotic compounds:** Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganics (metals, radionuclides, phosphates, nitrates) -- ecological considerations and decay.
- Unit 07. Biodegradation.** Problematic environmental contaminants and their characteristics -- synthetic detergents, pesticides, hydrocarbons, chlorinated aliphatic and aromatic hydrocarbons, polyaromatic hydrocarbons (PAHs), kerosene, diesel, lubricating oil.
- Unit 08. Bioremediation of soil and water.** Scope and characteristics of *ex situ* and *in situ* bioremediation. Bioremediation of soil & water contaminated with oil spills. Degradation of lignin and cellulose using microbes. Phytoremediation- types of reactors used. Degradation of pesticides and other toxic chemicals, aromatic and chlorinated hydrocarbons. Role of degradative plasmids and other molecular techniques in bioremediation. Role of immobilized cells/enzymes in treatment of toxic compounds. Use of biopesticides. Bioremediation of emerging pollutants. E-waste: definition, sources, composition, recycling and disposal.
- Unit 09. Treatment of municipal waste and industrial effluents.** Solid wastes - definition, origin, classification and characteristics; their segregation, collection, transportation, treatment and disposal--by composting/vermiculture, open dumping, sanitary landfill, incineration, recycling and recovery. Hazardous waste: Definition, sources, classification, effects and disposal methods. Reclamation of waste land. Use of biological processes to remove pollutants from waste water. Treatment schemes for waste waters of dairy, distillery, tannery, breweries, food processing industries, sugar, antibiotic industries and slaughter-houses. The national Solid waste Management Rules (2016) -- a brief idea.
- Unit 10. Novel and emerging technologies.** Use of microbes in Bio-energy production. Biohydrometallurgy and Bioleaching (Biomining); Synthetic Biology -- engineering microbes to perform new functions; Gene editing -- using CRISPR-Cas9 and other tools to modify microbial genomes; Nanomaterials -- using nanoparticles to enhance the performance of environmental biotechnological applications.
- Unit 11. Environmental monitoring, assessment and restoration practices.** Use of biological methods to monitor and assess environmental quality and restore degraded ecosystems. Measurement of pollution and its methods. Air quality standards -- NAAQS, AQI and Bharat Stage - VI emission standards. Air pollution abatement and odour control. Water quality criteria and indices; specifications for drinking-water quality. Noise pollution control measures. Use of biosensors, biopolymers, bioplastic and biochips.
- Unit 12. Environmental ethics and sustainability.** The Tragedy of Commons. Sustainable development. Ethical and sustainability implications of environmental biotechnological practices; a brief idea on UN sustainable development goals (SDG, 2030).
- Unit 13. Global warming and climate change mitigation.** Impending global catastrophe by climate change. Use of microbes to capture and store CO₂, to produce biofuels (to displace fossil fuels), to enhance crop yields, to develop new food products and to reduce food waste.
- Unit 14. International & National legislations and Policies for Environmental Protection.** A brief idea on the following: Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

declaration; Ramsar Convention (1971); Kyoto protocol (1997); UNFCCC Paris-(2015) & Glasgow (2021) agreement. National legislations -- Salient features of Wild Life Protection Act (1972), Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act-1981, Forest (Conservation) Act, 1980 with later amendments; Central and State Pollution Control Boards.

Discipline Specific Elective (DSE) Course

NEC-BT-01: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Biodiversity (Microbes, Algae, Fungi and Archegoniates)

- Unit 01.** Viruses – Discovery, general structure, importance and applications.
- Unit 02.** Bacteria–Introduction, general characteristics and cell structure; genetic recombination, importance and application.
- Unit 03.** Algae: General characteristics; range of thallus organization; economic importance of algae
- Unit 04.** Structural organization and life-cycles of the following genera: *Nostoc*, *Oedogonium*, *Polysiphonia*.
- Unit 05.** Fungi: Introduction; general characteristics, range of thallus organization, importance and applications.
- Unit 06.** Structural organization and life cycles of the following genera: *Penicillium* and *Agaricus*.
- Unit 07.** Mycorrhizae: Ectomycorrhiza and endomycorrhiza and their significance. Role in agriculture and forestry, lichen; general account.
- Unit 08.** Archegoniates: Introduction and unifying features.
- Unit 09.** Bryophytes: General characteristics; range of gametophytic thallus organization in liverworts, hornworts and mosses with examples.
- Unit 10.** Variations in sporophytes with examples; ecology and importance of bryophytes with emphasis on *Sphagnum*.
- Unit 11.** Pteridophytes: General characteristics; early land plants –*Cooksonia* and *Rhynia*;
- Unit 12.** Homosporous and heterosporous pteridophytes with examples; sori and sporocarp with examples; ecological and economical importance of Pteridophytes.
- Unit 13.** Gymnosperms: General characteristics; differences with pteridophytes and angiosperms.
- Unit 14.** Structure and reproduction in *Cycas* and *Pinus* (Developmental details not to be included). Ecological and economical importance.

NEC-BT-02: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Ecology and Taxonomy

- Unit 01.** Ecology; Definition and introduction.
- Unit 02.** Ecological factors: Brief knowledge about soil, water, light and temperature.
- Unit 03.** Adaptations of hydrophytes and xerophytes.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 04.** Plant communities: Characteristics; ecotone and edge effect; succession-processes and types.
- Unit 05.** Ecosystem: Structure; energy flow; trophic organization; food chains and food webs; ecological pyramids- production and productivity; ecosystem services.
- Unit 06.** Biogeochemical cycling; carbon, nitrogen, phosphorous and sulphur cycles.
- Unit 07.** Phytogeography: Principal phytogeographical zones of India; endemism.
- Unit 08.** Introduction to plant taxonomy: Identification, classification, nomenclature.
- Unit 09.** Identification: Functions of herbaria, important herbaria and botanical gardens of the world and India; documentation of flora, keys- single access and multi-access.
- Unit 10.** Taxonomic tools - application of palynological and cytological evidences in plant systematics. Taxonomic hierarchy: Ranks, categories and taxonomic groups.
- Unit 11.** Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid and effective publication, rejection of names, principle of priority and its limitations.
- Unit 12.** Types of classification- artificial, natural and phylogenetic and phenetic.
- Unit 13.** Study of one natural system of classification Bentham and Hooker's system of classification (up to series).
- Unit 14.** Six kingdoms three domains, tree of life, barcode phylogeny

NEC-BT-03: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Anatomy and Embryology

- Unit 01.** Tissues and tissue systems, Meristematic and permanent tissues: Root and shoot apical meristems.
- Unit 02.** Tissue; Simple and complex.
- Unit 03.** Primary Structure: Structure of dicot and monocot root stem and leaf.
- Unit 04.** Secondary Growth: Vascular cambium – structure and function, seasonal activity.
- Unit 05.** Secondary growth in root and stem, Wood (heartwood and sapwood).
- Unit 06.** Adaptive and protective systems: Epidermis, cuticle, stomata; general account of anatomical adaptations in relation to ecological types.
- Unit 07.** Flower: Structure and variations of anther and pollen; types of ovules.
- Unit 08.** Embryo sac: Types, organization and ultrastructure of a typical mature embryo sac.
- Unit 09.** Pollination: Pollination mechanisms and adaptations.
- Unit 10.** Fertilization: mechanism of double fertilization.
- Unit 11.** Seed, types, structures, appendage.
- Unit 12.** Endosperm: endosperm types, structure and functions.
- Unit 13.** Embryo: Dicot and monocot embryo; embryo-endosperm relationship.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

Unit 14. Apomixis and Polyembryony: Definition, types and Practical applications.

NEC-BT-04: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Economic Botany and Plant Biotechnology

Unit 01. Origin of Cultivated Plants: Concept of centres of origin, their importance with reference to 'Vavilov' centres of origin.

Unit 02. Cereals: Rice and wheat- origin, morphology, outlines of cultivation and uses.

Unit 03. Legumes: General account with special reference to Gram and soybean.

Unit 04. Spices: General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses).

Unit 05. Beverages: Tea (morphology, processing, uses).

Unit 06. Oils and Fats: General description with special reference to groundnut and mustard. .

Unit 07. Fiber Yielding Plants: General description with special reference to cotton , jute (botanical name, family, parts used, morphology and uses).

Unit 08. Introduction to biotechnology: History, aims and scopes.

Unit 09. Plant tissue culture: Basic principles, totipotency, callus culture, meristem culture, organ culture.

Unit 10. Micropropagation ; haploid and dihaploid production through androgenesis and gynogenesis.

Unit 11. Embryo and endosperm culture, applications.

Unit 12. Recombinant DNA Techniques: Basic principles and tools- RE, plasmid vector, cloning, genomic library, screening.

Unit 13. Blotting techniques: Northern, Southern and Western Blotting.

Unit 14. DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR.

Multi-Disciplinary Course (MDC)

NMD-BT-01: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Plant Diversity and Human Welfare

Unit 01. Plant diversity and its scope- Plant diversity, agro-biodiversity and cultivated plants; their significance at the ecosystem level, biodiversity hotspots.

Unit 02. Agro-biodiversity and cultivated plant taxa, wild taxa. Values and uses of biodiversity: ethical and aesthetic values, precautionary principle.

Unit 03. Uses of plants, uses of microbes.

Unit 04. Loss of Biodiversity- loss of genetic diversity, loss of species diversity, loss of ecosystem diversity, loss of agro-biodiversity, projected scenario for biodiversity loss.

Unit 05. Management of plant Biodiversity- organizations associated with biodiversity

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

management and methodologies for execution, IUCN, UNEP, UNESCO, WWF, NBPGR.

- Unit 06.** Biodiversity legislation and conservations, biodiversity information management and communication.
- Unit 07.** Conservation of Biodiversity: Conservation of ecosystem diversity social approach.
- Unit 08.** In situ and ex situ conservation, awareness programs, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.
- Unit 09.** Plant diversity in changing world; introduction , species composition, threatened species, major threats, habitat loss, habitat fragmentation, and degradation, overexploitation , invasive species, air pollution and climate change,
- Unit 10.** Plants and human Welfare- importance of forestry, benefits, management and commercial aspects.
- Unit 11.** Plantation strategies- a) Avenue trees, b) Ornamental plants c) nursery d) kitchen garden e) sacred groves; definition role in conservation.
- Unit 12.** Some important medicinal plants, role of medicinal plants in traditional and modern medicine- Sarpagandha, Kalmegh, Vasaka, Guduchi/Gulancha, Chirayita and Anantamul.
- Unit 13.** Fruits and nuts: Important fruit crops of India and their commercial importance. Alcoholic beverages through the ages.
- Unit 14.** Wood-timber yielding plants.

Skill Enhancement Course (SEC)

NSE-BT-01: (Credit-4 / Marks-100; TEE-70; ASSGN-30)

Medicinal Botany

- Unit 01.** History, scope and importance of medicinal plants- indigenous medicinal plants; their uses, pharmacopoeia, BP and IP
- Unit 02.** Ayurveda: history, origin, panchamahabhutas, saptadhatu and tridosha concepts, rasayana, plants used in ayurvedic treatments,
- Unit 03.** Siddha: Origin of siddha medicinal systems, basis of Siddha system, plants used in siddha medicine. Unani: history and concepts- Umoor-e-tabiya, tumors treatments/therapy, polyherbal formulations.
- Unit 04.** Conservation of endangered and endemic medicinal plants- definition and examples of endemic and endangered medicinal plants, red data list - criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanical gardens, ethnomedicinal plant gardens.
- Unit 05.** Propagation of medicinal plants- objectives of the nursery, classification and important components of a nursery, sowing, pricking, use of green house, Propagation through cuttings, layering, grafting and budding.
- Unit 06.** Ethnobotany and folk medicines- definition and history of ethnobotany in India, Palaeo-ethnobotany.
- Unit 07.** Methods to study ethnobotany; basic idea on the ethnic communities of India.

Netaji Subhas Open University

Four-year Undergraduate program in Botany

Syllabus

- Unit 08.** Folk medicines, ethnoecology and importance of interactions between the regions of the nation.
- Unit 09.** Application of natural products in treatment of certain diseases- jaundice, cardiac problems, infertility.
- Unit 10.** Application of natural products in controlling diabetes, hypertension and skin diseases.
- Unit 11.** Some important medicinal plants of India with their geographical distribution and uses – *Acorus calamus* (Bach), *Justicia adhatoda* (Vasaka), *Aloe vera* (Ghritakumari), *Atropa belladonna* (Belladonna), *Cymbopogon citratus* (Dhanwantari), *Phyllanthus urinaria* (Hazarmani), *Stephania japonica* (Akandi) and *Withania somnifera* (Aswagandha).
- Unit 12.** Medicinal plants and polyherbal formulations – brief introduction about polyherbal formulations with examples
- Unit 13.** MPCA and Medicinal plants conservation – What are MPCAs (Medicinal Plants Conservation Areas)? MPCAs in West Bengal, Steps to execute MPCA programme, Criteria of selecting MPCA Sites, Role of MPCAs in the conservation of locally threatened medicinal plants.
- Unit 14.** Plant secondary metabolites of medicinal importance – alkaloids, flavonoids and terpenoids (brief account with examples).