Netaji Subhas Open University
Honours in Botany
Programme Code - HBT

Programme Objectives

Three years CBCS B.Sc. Botany Hons. programme is formulated for developing competent botanist for which significant job opportunities exist in this country. The programme is interdisciplinary in nature. The learner graduating with the Degree B.Sc. in Botany (Hons.) should be able to acquire-

✓ **Core competency:**

▪ Botany being an integral part of studies in Biological sciences, the learners will gain from core knowledge in general on all fundamental processes that encompass life and will acquire competency in the subject Botany and all allied areas of Life Sciences. The student will become familiar with all major plant groups, will be able to compare them and will benefit from critical knowledge on their forms, classification, characterization and exploitation.

▪ Students will become familiar with the world of microorganisms and the programme will keep themselves abreast with classical as well as modern developments in the microbiology, particularly in relation to the huge role they play in sustaining the living world.

▪ Learners will be able to use the evidence based comparative botany approach to explain the evolution of organism and understand the genetic diversity on the earth**.**

▪ Students will be able to explain various plant physiological processes and functions, metabolism, concepts of gene, genome and how an organism's function is influenced at the levels of cells, tissues and organs respectively.

▪ Learners will be able to understand adaptation, development, and behavior of different forms of life. The understanding of networked life on earth and tracing the energy pyramids through nutrient flow will make the learner better equipped specialists in sustenance and improvement of environment both in micro and macro level.

▪ Learners will have plenty of opportunities in gaining hands on training in modern biological techniques through an integrated demonstration and application-based core curriculum.

✓ **Analytical ability:**

▪ Learners will be able to demonstrate the knowledge in understanding research and addressing practical problems.

✓ Critical Thinking and problem-solving ability:

▪ At the end of this programme, Learners will become critical thinker and acquire problem solving capabilities.

✓ Digitally equipped:

▪ Learners will acquire digital skills and integrate the fundamental concepts with modern tools. They will familiar with different educational platform viz. SWAYAM, MOOCs, NSOU_LMS, NSOU_e-Resources (digital library), NSOU_Mobile apps etc.

✓ Ethical and Psychological strengthening:

▪ Learners will also strengthen their ethical and moral values and shall be able to deal with different psychological weaknesses. It will be helpful to prepare the students to accept the challenges in upcoming life.

✓ Social Interaction:

▪ Learners will learn team workmanship in order to serve the institutions, industry and society more efficiently. Elicit views of others, mediate disagreements and help reach conclusions in group settings.

✓ Environment and Sustainability:

▪ Learners will be able to understand the issues of environmental contexts and sustainable development.

✓ Independent Learner:

▪ Apart from the subject specific skills, generic skills, especially in botany, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations, and employment. Learning outcomes-based curriculum would ensure equal academic standards across the country and broader picture of their competencies. The freshers and existing workforce can take the advantage of ODL system to increase their skills and competencies without disturbing their work schedule.

Expected Programme Outcome

The goal of the HBT syllabus is to make the study of Botany popular, interesting, and encouraging to the learners for higher studies including research. The new and updated syllabus for all the three years are based on a basic and applied approach with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other Universities and the needs of industries and research. The Core Courses (CC) would strengthen the learners with in-depth subject knowledge. Concurrently, the Discipline Specific Electives (DSE) will add additional knowledge about applied aspects of the program as well as its

applicability in both academia and industry. Generic Electives (GE) will introduce integration among various interdisciplinary courses. The Skill Enhancement Courses (SEC) would add additional skills related to the subject as well as those from outside the purview of the subject. After successful completion, the student graduated with this curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, entrepreneurship and Industry. The curriculum is aimed at enhancing the employability of B.Sc. Botany graduate, as due importance is given to the development of core competence in the subject matter, both theoretical and practical, in relation to demand and outlook of the society. To expand the employability of graduates, a number of skill development courses have also been introduced in this framework.

Programme Structure

	SEM	CODE	Course Name	Theory/ Prac.	Credit	Study Hours	TEE Full Marks	Assignment Full Marks	Total Marks	Pass Marks 30%
1st Year	I	CC-BT-01	1. Phycology, Microbiology 2. Mycology and Phytopathology, 3. Archegoniatae	Practical	6	180	70	00	70	21
		CC-BT-02	Phycology, Microbiology	Theory	6	180	50	20	70	21
		AE-BG-11 /AE-EG-12	Bengali/English*	Theory	2	60	50	20	70	21
		#GEC-01	Refer Table Below	Theory	6	180	50	20	70	21
	II	CC-BT-03	Mycology & Phytopathology	Theory	6	180	50	20	70	21
		CC-BT-04	Archegoniatae	Theory	6	180	50	20	70	21
		AE-ES-21	Environmental Studies	Theory	2	60	50	20	70	21
		#GEC - 02	Refer Table Below	Theory	6	180	50	20	70	21

2nd Year	**III**	**CC-BT-05**	1. Anatomy, Economic Botany 2.Morphology, Plant Systematics 3. Plant Ecology and Phytogeography	Practical	6	180	70	00	70	21
		CC-BT-06	1. Biomolecules and Plant Metabolism 2. Plant Physiology, Reproductive Biology of Angiosperms	Practical	6	180	70	00	70	21
		CC-BT-07	Anatomy, Economic Botany	Theory	6	180	50	20	70	21
		SE-BT-11	Medicinal Botany	Theory	2	60	50	10	60	18
		#GEC- 03	Refer Table Below	Theory	6	180	50	20	70	21
	IV	**CC-BT-08**	Morphology, Plant Systematics	Theory	6	180	50	20	70	21
		CC-BT-09	Plant Physiology, Reproductive Biology of Angiosperms	Theory	6	180	50	20	70	21
		CC-BT-10	Biomolecules, Plant Metabolism	Theory	6	180	50	20	70	21
		SE-BT-21	Plant Diversity and Human Welfare	Theory	2	60	50	10	60	18
		#GEC- 04	Refer Table Below	Theory	6	180	50	20	70	21
3rd Year	**V**	**CC-BT-11**	1. Cell Biology 2. Plant Biotechnology 3. Genetics and Molecular Biology	Practical	6	180	70	00	70	21
		CC-BT-12	Genetics and Molecular Biology	Theory	6	180	50	20	70	21

		DS-BT-11	Stress Biology	Theory	6	180	50	20	70	21
		DS-BT-21	1. Stress Biology 2. Natural Resource Management 3. Plant Breeding	Practical	6	180	70	00	70	21
	VI	**CC-BT-13**	Plant Ecology and Phytogeography	Theory	6	180	50	20	70	21
		CC-BT-14	Cell Biology, Plant Biotechnology	Theory	6	180	50	20	70	21
		DS-BT-31	Plant Breeding	Theory	6	180	50	20	70	21
		DS-BT-41	Natural Resource Management	Theory	6	180	50	20	70	21
	TOTAL				**140**				**1800**	

*Learners will choose any one from AE-BG-11: Bengali or AE-EG-12: English as Ability Enhancement Compulsory Course 1

#Any one from each group (column) to be selected from the following

Option of GE courses for HBT

Subject	**SEM-I: GE-01**	**SEM-II: GE-02**	**SEM-III: GE-03**	**SEM-IV: GE-04**
Zoology	**GE-ZO-11:** Animal Diversity	**GE-ZO-21:** Aquatic Biology	**GE-ZO-31:** Insect Vector and Disease	**GE-ZO-41:** Food, Nutrition and Health
Chemistry	**GE-CH-11:** Basic Physical Chemistry	**GE-CH-21:** Basic Inorganic Chemistry	**GE-CH-31:** Basic Organic Chemistry	**GE-CH-41:** Application Oriented Chemistry **GE-CH-42:** Approved MOOCs'

Examination System Per Semester

Term-End Examination Dec. (Odd Sem July-Dec.)

Semester I	Semester III	Semester V
CC1 CC2 AECC1 (Beng/ Eng) GEC1 Total credit: 20	CC5 CC6 CC7 SEC1 GEC3 Total credit: 26	CC11 CC12 DSEC1 DSEC2 Total credit: 24

Term-End Examination June (Even Sem Jan-June)

Semester II	Semester IV	Semester VI
CC3 CC4 AECC2 (ENVS) GEC2 Total credit: 20	CC8 CC9 CC10 SEC2 GEC4 Total credit: 26	CC13 CC14 DSEC3 DSEC4 Total credit: 24

*****Assignment will be conducted through digital platform on MCQ***

Objective and Expected Outcome for Each Course

Course Code	Course Objectives	Expected Outcomes
Core Courses		
CC-BT-01	• To impart hands on training to properly use of microscope (compound light) at different magnifications. • To find out the magnification and dimension of the observed object. • To learn preparation of culture media, inoculation and grow in culture. • To learn basic staining procedure of various microorganisms like bacteria, algae and fungi. • To work out external morphology of vegetative and reproductive structures, identifying characters of selected genera (representatives of major groups) of bryophytes, pteridophytes and gymnosperms.	• At the end of the course on practical training students will be able to handle some basic instruments like microscope, laminar air flow, autoclave, BOD, pH Meter, Distillation Unit etc. • The student will be able to prepare slides of microorganisms for microscopic studies. • The student will be able to note identifying characters from permanent slides of various plant materials. • The student will be able to describe the

		identifying characters from whole mount of vegetative and reproductive structures of major groups of archegoniates.
CC-BT-02	• To make the student understand the historical development of these two subjects. • To highlight the fundamental structural aspects of prokaryotic and eukaryotic cells and basic cellular organisation of a microorganism. • To understand modern classification system of microorganisms and their phylogenetic relationship. • To study salient features of major algal divisions and life-cycle pattern of selected genera representing these divisions. • To study discovery, ultrastructure and cyclic process of regeneration of virus, prion and viroids. • To develop fundamental concept of bacterial cell structure, growth and reproduction, genetic recombination, bacterial systematics (major groups), microbial ecology. • To study the practical application of basic knowledge of microbiology.	• The student will have the latest information regarding the basic organisation of a cell and difference between prokaryotic and eukaryotic organisation, their origin and significance in systematics. • The student will understand the fundamentals of origin of diversity among microorganisms, basic ultrastructure and biochemical pathways and their phylogenetic relationships. • Knowledge of ecological habitats of various microorganisms and their survival strategy will enable the student to find out the disease cycle and remediation. • Knowledge of genetic recombination will enable a student to understand the finer points of recombinant technology. • Study of the above aspects will enrich their knowledge regarding practical applicability.
CC-BT-03	• To develop clear concept of Kingdom – Fungi and fungal classification.	• The student will have a clear concept of the kingdom-Fungi and its

	• To know the ultrastructural features of fungal cell, nutritional aspects, growth and reproduction. • To study the general features, habitat, reproduction of major fungal divisions. • To study the life-cycle patterns of representative genera of all the divisions. • To study the general features of Myxomycota, Lichens and Mycorrhiza. • To study fungal biotechnology with special reference to mushroom culture. • To know the definitions of all terms related to phytopathology. • To know the terminology related to symptoms of plant diseases, spread of disease. • To know the defence mechanism in plants. • To study some common plant diseases of India, their causal organism, disease cycle, symptoms and control measure.	differences with plants (Kingdom – Plantae). • The student will come to know about the vegetative and reproductive differences between major fungal groups. • They will also have a knowledge of homothallic and heterothallic species and degeneration of sex in fungi. • The students will develop clear concept of fungal diseases with special regard to disease cycle, inoculum pattern, control and effect of environment. • They will also develop clear concept regarding effect of fungal diseases on crop production particularly in Indian context.
CC-BT-04	• To understand the concept of archegoniates and salient feature. • To distinguish between three major groups – Bryophytes, Pteridophytes and Gymnosperms and classify them upto classes. • To study the general characteristics of the above mentioned three groups, their classification and life-history of selected representative genera. • To conceptualize origin of land plant and know about the early land plants. • To know about general topics like apospory, apogamy, heterospory and seed habit, telome theory and stelar evolution. • To know about process of fossilization and some selected fossil genera.	• The students will come to know about invasion of land, development of land flora. • They will come to know about the embryo formation in different groups. • They will develop an idea of sporophyte dominant life-cycle pattern in land plants. • They learn about the theories of origin of life-cycle, seed habit, apospory, apogamy, telome theory an evolution of stele.

	• To know about general features of gymnopserms, their classification. • To know about ecological and economic importance of the archegoniate groups.	• They will know about the distribution of bryophytes, pteridophytes and gymnosperms. • They will understand the ecological and economic importance of these three groups of land plants.
CC-BT-05	• To develop a concept of various components of primary and secondary plant body. • To identify anatomical features of permanent tissue like parenchyma, sclerenchyma, sclerides, tracheids, trachaea, sieve tubes etc. • To identify different types of vascular bundles, stomata, trichomes. • To study secondary growth in selected plant species and find out ecological significance of some anatomical features. • To develop knowledge about the plants yielding beverages, essential oils, rubber, drugs and sketch them. • To study morphology of plants with special reference to cohesion and adhesion of stamens and carpels, types of inflorescences and placentation. • To study taxonomically significant features of some angiosperms representing different families. • To learn some basic techniques related to plant ecology and phytogeography like, community structure by quadrat method, preparation of herbarium, determination of physico-chemical parameters of soil.	• The student will have knowledge to distinguish anatomically root, stem, dicot and monocot features. • The student will learn to identify basic components of primary and secondary structures in angiosperms. • The student will acquire good knowledge of economic use of some important plants. • The student will acquire good knowledge of taxonomically significant characters of angiosperms. • The student will have hand on training of some basic ecological methods.
CC-BT-06	• To learn detection of various organic acids, carbohydrates, protein from plant sample. • To detect metals like Ca, Mg, Fe, S from plant sample.	• The student will learn basic procedures for detection of organic acids, organic compounds, metals from plant material.

	• To learn estimation of dissolved oxygen from water sample. • To learn estimation of catalase from plant material. • To learn preparation of solutions of different concentration. • To learn demonstration of osmotic pressure by plasmolytic method; determination of OP by gravimetric method and other experiments related to plant physiology. • To demonstrate imbibition of water by seed; determination of seed viability (TTC test). • To determine rate of aerobic respiration, transpiration and $Q_{10.}$ • To learn preparation of slides showing ornamentation and apertures of pollen grain; study of pollinia	• The student will be able to estimate dissolved oxygen in aquatic environment. • The student will learn estimation of enzyme like catalase under stress condition. • The student will learn measurement of Osmotic Pressure; detect seed viability. • The student will learn fundamentals of pollen identification from temporary and permanent slides.
CC-BT-07	• To develop clear concept regarding plant cell wall (primary and secondary); tissue types with function. • To understand structure and function of root and shoot tips. • To locate mechanical tissues in plant. • To know stomatal types and associated cells. • To know stelar types and evolution of stele. • To understand role of cambium and development of primary and secondary structure. • To understand secondary growth in stem and root. • To study anomalous secondary growth in selected species. • To study anatomical adaptation in xerophytes and hydrophytes	• The student will develop clear idea about plant cell wall structure which has many variations. • The student will understand root and stem growth, both primary and secondary. • The student will have clear idea about role of cambium in plant growth. • The student will have clear idea about secondary growth and anomalous secondary growth. • The student will able to discuss different anatomical adaptation.
CC-BT-08	• To study morphological features of different parts of an angiosperm plant. • To study different types of inflorescences with example. • To study a flower with reference to adhesion and cohesion of stamens.	• The student will come to know about detail morphological features of an angiosperm with special reference to flower, inflorescence

	• To study of various placentation types of ovules. • To study the different types of fruits and seed. • To know definition of taxonomy, systematics, classification, identification, nomenclature. • To conceptualize artificial, natural and phylogenetic classification and know their broad features including APG classification. • To know the significance of herbarium and botanical garden. • To know the diagnostic features and systematic position of some selected families. • To gather taxonomic evidences from different fields of plant biology. • To understand numerical taxonomy, phenogram, cladistics and cladogram.	and significant taxonomic feature. • The student will have clear concept of artificial, natural and phylogenetic classification. • The student will come to know about diagnostic features and systemic position of some important angiospermic family. • The student will understand the practical utility of herbaria and botanical garden. • The student will understand acquire preliminary knowledge of phenogram, cladogram and process of establishing phylogenetic relationship.
CC-BT-09	• To acquire introductory knowledge of cell physiology with special emphasis on cell membrane, water potential, imbibition, osmosis, plasmolysis. • To acquire basic knowledge about molecular and physical properties of water; absorption of water by land plant. • To know different theories of ascent of sap. • To understand various aspects of transpiration. • To know the essential and non-essential elements concerned with mineral nutrition of plants. • To understand mechanism of translocation of organic materials in plants. • To know basic aspects of plant growth and its measurement. • To study fundamentals of photosynthesis – light reactions, Calvin	• The student will have detail knowledge about the most significant topics of cell physiology. • The student will acquire knowledge of fundamental physiological processes of angiosperms – photosynthesis, respiration, plant movement, mineral nutrition, translocation, plant movement, photoperiodism. • The students will come to know about seed biology and seed germination. • The student will understand mechanism

	cycle, electron transport chain and ATP generation, CAM pathway and bacterial photosynthesis. • To study fundamentals of respiration – glycolysis, Krebs cycle, photorespiration. • To study biological nitrogen fixation, concept of nif genes. • To study plant movements -tropic, nastic, tirgor. • To study photoperiodism – critical day length, vernalization, role of phytochrome in flowering. • To understand basics of seed physiology - germination, dormancy, biochemical changes during germination. • To study topics related to reproductive biology – pollination, development of male and female gametophyte; apomixis; cybrids.	of flowering and critical aspects of reproductive biology.
CC-BT-10	• To understand structural and functional aspects of carbohydrates, lipids and proteins. • To understand structure of nucleic acids. • To understand fundamentals of bioenergetics – laws of thermodynamics, endergonic and exergonic reactions, redox reactions. • To understand structure of ATP and its role as energy currency. • To know definition pH, buffer. • To know properties and primary structure of amino acids. • To know properties and structure of enzymes, enzyme inhibition, definition of – holoenzyme, apoenzyme, co-factor, co-enzyme, prosthetic group, classification of enzymes, theories of mechanism of action, Michelis-Menten equation. • To know basics of plant pigments.	• The student will understand structure and function of biomolecules and their role in biochemical pathways. • The student will acquire knowledge of bioenergetics, function of ATP and its generation. • The student will gather knowledge of enzyme – properties, theories of mechanism of action, classification, and components of an enzyme. • The student will have knowledge of plant pigments – their structure and function.
CC-BT-11	• To study mitotic chromosomes from squash preparations after pretreatment, fixation and staining. • To determine mitotic index.	• The student will learn to workout mitotic and meiotic chromosomes from selected plant

	• To learn temporary smear preparation from flower buds and identification of meiotic stages. • To study anther, embryo and endosperm culture. • To study micropropagation, embryogenesis through photographs. • To study steps of genetic engineering for production of Bt cotton, golden rice, Flavr-Savr tomato. • To determine mean, SD and SE from samples. • To determine goodness of fit in normal and modified monohybrid and dihybrid ratio. • To study structure of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photograph. • To know about the component of Murashige and Skoog (MS) medium.	species; squash and smear techniques. • The student will come to know the fundamentals of micropropagation and embryogenesis. • The student will come to know about the fundamentals of recombinant technology. • The student will learn basics of biometry. • The student will learn the experimental design to establish DNA as genetic material. • The student will learn to prepare MS medium.
CC-BT-12	• To learn fundamentals of Mendelism; chromosome theory of inheritance; gene interaction, dominance, and related terms; multiple alleles, allelic contemplation test. • To know definition and different types of epistasis, pleiotropy, penetrance and expressivity; polygenic inheritance, environment and gene expression. • To know the fundamentals of linkage, crossing over and chromosome mapping; extra-cellular inheritance with specific example. • To know structure and organization of eukaryotic chromosome and techniques like banding and FISH. • To understand polyploidy and aneuploidy and various ways to bring about chromosomal structural changes. • To understand mutation – molecular basis and detection. • To understand modern concept of gene and genetic code. • To understand basis of population and evolutionary genetics.	• The student will learn fundamentals of mendelism; chromosome theory of inheritance; gene interaction, dominance, and related terms. • The student will understand allele, multiple alleles, allelic contemplation test, epistasis, penetrance, expressivity, pleiotropy. • The student will understand linkage, crossing-over, chromosome mapping; extracellular inheritance. • The student will study various aspects of polyploidy and aneuploidy; chromosomal changes; mutation – molecular mechanism and detection.

	• To know how DNA was established as the genetic material; nucleosome model; denaturation, renaturation, cot curves. • To know basis of DNA replication, gene expression, regulation. • To know the basics of transposable elements and plasmids; restriction endonuclease and recombinant DNA technology; Genomic library and RFLP.	• The student will understand modern concept of gene and gene action. • The student will understand gene expression and regulation; transposable elements. • The student will know genomic library and RFLP.
CC-BT-13	• To reveal the interrelationship between plant ecology and human civilization. • To conceptualize the basis of an ecosystem, its abiotic and biotic components and energy flow. • To know the pathways of carbon, nitrogen and phosphorus cycle and their role. • To know the plant communities, community dynamics, plant succession. • To know the role of ecological factors; origin and composition of soil; state of water in environment; role of light and temperature. • To understand fundamental aspects of atmosphere, various groups of plants on the basis of their response to atmosphere. • To understand the basis of environmental pollution, its impact on plants, global environmental issues like global warming, ozone depletion.	• The student will have a clear understanding of ecological factors (biotic and abiotic) and their relationship with plant growth and its effect on human life. • The student will understand fundamentals of various ecosystems on earth and their functioning. • The student with knowledge acquired regarding the plant ecology, ecosystem, plant communities will have a better knowledge of environment. • The student with basic knowledge of requirements of plant community as a whole will understand the environmental pollution and its adverse effect on plant growth.
CC-BT-14	• To acquire knowledge about the working principle of Light, Phase contrast, Fluorescence, Electron and Confocal microscopy. • To study the organization of a eukaryotic cell, functioning of cellular	• The student will have preliminary knowledge of various kinds of microscopy and their application in revealing the cellular and membrane structure.

	organelles and their chemical components. • To study the ultrastructure of various cellular organelles with special reference to nucleus, ribosome, mitochondria, chloroplast, endomembrane system and Golgi body. • To study the cell division – both mitosis and meiosis, and the significance in maintaining chromosome number. • To know the significance of cell cycle and its control.	• The student will understand the detail of ultrastructure of cellular organelles and the functional aspect of each sub-cellular component. • The student with the knowledge of detail steps of meiosis and mitosis will also understand the basics of genetics. • The student with basic knowledge of cell cycle will understand cancerous growth.
Discipline Specific Elective Courses		
DS-BT-11	• To define acclimation and adaptation in plant stress. • To understand environmental factors, like- water stress, salinity stress, temperature stress; pathogenesis related protein; mediation of insect and disease resistance by jasmonates. • To understand stress sensing mechanism in plants. • To understand developmental and physiological mechanisms that protect plants against environmental stress.	• The learners will understand role of various environmental factors to create stressful condition. • The students will know about stress sensing mechanisms. • The learners understand the various mechanisms to protect itself from stress.
DS-BT-21	To learn the following techniques related to stress biology / natural resource management/plant breeding. • Quantitative estimation of peroxidise and superoxide activity in seedling. • Quantitative estimation and zymographic analysis of catalase and glutathione reductase. • Estimation of solid waste generated by domestic system. • Collection of forest data. • Measurement of dominance of wood species by DBH method. • Calculation of mean, standard deviation and standard error, correlation co-efficient value; F-value, probability value.	The learners will equip himself with following techniques and will be able to perform experiments • Enzyme estimation in stress. • Solid waste estimation. • Calculation related to statistical analysis.

DS-BT-31	• To understand breeding systems in plants; modes of reproduction crop plants; consequences of plant breading. • To know about various methods of crop improvement; develop idea regarding centre of origin, plant genetic resources; selection method for self-pollinated and cross-pollinated plants; methods of hybridization. • To know about quantitative inheritance with inheritance of Kernel colour in wheat, skin colour in human; monogenic and polygenic inheritance. • To know about genetic basis of inbreeding depression and heterosis. • To know various methods of crop improvement - mutation, hybridization and biotechnology.	The learners will have knowledge about the following aspects of plant breeding - • Modes of reproduction and breeding systems. • Various methods of crop improvement - mutation, hybridization and biotechnology. • Quantitative inheritance. • Genetic basis of inbreeding depression and heterosis.
DS-BT-41	• To know definition and types of natural resources. • To develop concept of sustainable utilization. • To develop concept of land utilization, soil degradation and management. • To know about fresh water system; threats and management. • To know about different types of biodiversity, threat management, bio-prospecting; IPR, CBD, National biodiversity action plan; national and international resource management and conservation.	The learners will have knowledge about the following aspects of natural resource management - • Types of natural resources. • Different approaches of sustainable utilization. • Sustainable utilization of different types of Land, Water bodies and forests. • Various national and international efforts for conservation of biological resources.
Skill Enhancement Courses		
SE-BT-11	• To know about scope and importance of medicinal plants and historical developments. • To know about indigenous medicinal sciences - Ayurveda, Siddha, Unani and treatments. • To know about conservation of endangered and endemic medicinal plants; in-situ conservation - Biosphere reserves, sacred groves etc.; ex situ conservation - Botanic gardens, ethno-medicinal plant gardens; propagation of medicinal plants, nursery.	The student will come to know about the following aspects of Medicinal Botany. • Scope and importance of medicinal plants. • Indigenous medicinal systems and their method of application.

	• To know about ethnobotany and folk medicine - ethnobotany in India; methods of study; ethnomedicine in ethnic communities in India; application of natural products.	• Thorough knowledge of conservation of endangered plants. • Ethnobotany and folk medicine.
SE-BT-21	• To develop clear idea about genetic, species and ecological diversity; agro-biodiversity and cultivated plant taxa; values of biodiversity, methodologies for valuation; uses of plants and microbes. • To know various ways of loss of biodiversity, ecosystem; management of plant biodiversity; IUCN, UNEP, UNESCO, WWF, NBPGR; biodiversity information management and communication. • To know various methods of biodiversity conservation. • To role of plants in relation to human welfare-avenue trees, Ornamental plants, alcoholic beverages: fruit & nuts; wood and its uses.	The student will learn the following aspects • Genetic, Species and ecological diversity and its value. • Loss and conservation of biodiversity. • Use of plants in human welfare.
Generic Elective Courses		
GE-BT-11	• To know about general characteristics of discovery, structure and economic importance of Virus and Bacteria. • To know about general characteristics, range of thallus organization, morphology, life-cycles and economic importance of selected genera of cyanobacteria and algae. • To know about general characteristics, range of thallus organization and life-cycle of selected genera of Fungi; Mycorrhiza and their significance. • To know about general characteristics of archegoniates. • To know about general characters, range of thallus structure of bryophytes with special reference to ***Sphagnum***; ecological and economic importance. • To know about general characteristics and economic importance of pteridophytes; early land plants like ***Cooksonia***, ***Rhynia***. • To know about general characteristics of Gymnosperm with special reference	• The learners will have very fundamental knowledge about the major plant groups having archegonium and other groups like Algae, Fungi, Bacteria and Virus. • The student will study- Representative genera of each group will be studied with special reference to Thallus organization, life-cycle, ecological and economic importance.

	to ***Cycas*** and ***Pinus***; their ecological and economic importance.	
GE-BT-21	• To develop basic concept in ecology and some terminology. • To know about ecological factors and adaptation of hydrophytes and Xerophytes. • To develop concept about plant communities, ecotone, succession - types and process. • To understand basics of various ecosystem with special reference to structure, energy flow in trophic organization, food chain, webs; ecological pyramids; biogeochemical cycling, carbon, nitrogen and phosphorus cycles. • To know fundamentals of phytogeography - biogeographical zones, endemism.. • To develop concept of plant identification, clarification, nomenclature. • To learn about taxonomic evidences - palynology, cytology. • To know about binomial system, typification, author citation, valid publication; principles and rules of ICN. • To understand artificial, natural and phylogenetic classification with special reference to Bentham and Hooker system.	The student have fundamental knowledge of ecosystem, physiological and anatomical adaptations of hydrophytes and xerophytes; concept of various plant communities; biogeochemical cycling, C -, N-, P-cycles. The student will have clear idea about community structure and plant succession. The student will acquire knowledge about bio-geographical zones, endemism. The student will gain knowledge about plant taxonomy-definition, system of various classification.
GE-BT-31	• To develop clear idea about dicot & monocot root, stem and leaf. • To conceptualize meristematic and permanent tissue. • To underhand tie of vascular cambium and secondary growth; wood. • To know about anatomical adaptive protective systems. • To study structural organization of flower; pollination and fertilization. • To study embryo and endosperm formation; Apomixis and polyembryony.	The student will have clear concept about the following aspects of Plant anatomy and embryology - • Structural organization of root, stem and leaf. • Secondary growth and role of cambium. • Adaptive and protective anatomical features.

		• Structural organization of flower, ovule, embryo sac, mature embryo. • Types of embryo, dicot and monocot embryo. • Apomixis and polyembryony.
GE-BT-41	• To conceptualize center of origin of a crop (Wheat); Vavilov's work; their uses. • •To know general account of legumes, spices, beverages, oil and fat yielding plants, fiber-yielding plants with reference to their botanical name, family, parts used, morphology and uses. • To know fundamental of biotechnology; plant tissue culture - micropropagation, haploid production, embryo and endosperm culture and application. • To Know the basics of recombinant DNA techniques - Northern, Southern, Western blotting, DNA fingerprinting; RAPD, RFLP, SNP; DNA sequencing, PCR.	The student will come to know about the fundamentals of • Origin of crop plants. • Detail features of economically important plants. • Understand the techniques related to molecular biology. • Basics of biotechnology with special reference to plant biotechnology.

Detailed Syllabus

Semester-I

Core Course-1 (Practical) Credit-6, Full Marks-70

Course Code: CC-BT-01, Course Title: Practical (Phycology and Microbiology; Mycology and Phytopathology; Archegoniatae)

Unit-1: Microscopy and Micrometry.
Unit-2: Bacterial Sample Preparation and Gram Staining (Curd).
Unit-3: Preparation and identification: ***Nostoc***, ***Oedogonium*** and ***Ectocarpus***.
Unit-4: Study of ***Vaucheria*** and ***Polysiphonia***.
Unit-5: Preparation and identification: ***Rhizopus*** and ***Ascobolus***.
Unit-6: Study of reproductive stages of ***Penicillium***, ***Puccinia*** and ***Agaricus*** and study of morphological types of Lichens.
Unit-7: Sterilization and inoculation techniques. Preparation of Culture Media (slants and stabs).
Unit-8: Study of some diseased plant specimens: **Late blight of potato**, **Stem rust of wheat**, **Brown spot of rice**.
Unit-9: Work out and identification of ***Marchantia***.
Unit-10: Study of permanent slides of vegetative and reproductive stages of ***Riccia***,

Anthoceros and ***Funaria***.

Unit-11: Work out and identification of ***Lycopodium*** and ***Pteris***.

Unit-12: Identification of ***Selaginella***, ***Equisetum*** and ***Calamites***.

Unit-13: External Morphological study, description and identification of ***Cycas*** and ***Pinus***; vertical section of ovule of ***Gnetum***.

Unit-14: Description of T.S of stem of ***Lyginopteris*** and ***Vertebraria***. Description of leaf of ***Glossopteris***.

Semester-I

Core Course-2 (Theory) Credit-6, Full Marks-70

Course Code: CC-BT-02, Course Title: Phycology and Microbiology

Module 1: Phycology

Unit-1: 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; concept of endosymbiosis (SET theory) and origin of algal chloroplast.

Unit-2: Modern criteria of algal classification; classification systems by Fritsch (1935, 1945), Bold and Wynne(1985) and Lee (2008).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-3: Modes of reproduction and life cycle patterns in algae.

Unit-4: C**yanophyta**: General characteristics, cells ultra-structure; heterocyst-structure and function Cyanobacterial genetic recombination. Prochloron and its evolutionary status.

Unit-5: Chlorophyta: General characteristics, life cycle of ***Chlamydomonas***, ***Volvox*** and ***Oedogonium***.

Unit-6: Charophyta: Characteristic features; life cycle of ***Coleochaete*** and ***Chara***; evolutionary significance of charophytes in origin of land plants.

Unit-7: Xanthophyta: General characteristic; life cycle of ***Vaucheria***.

Unit-8: Bacillariophyta: General characteristic; cell structure; auxospore formation; economic importance of Diatoms including Diatomaceous earth.

Unit-9: 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); nutritional types of nucleic acids in viruses (Baltimore classification).

Unit-12: Virus-II: Bacteriophages – structure, life cycle and lysogenic cycle, plant viruses – structure and transmissions of TMV, viroids 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: Bacteria genome, Nucleoid and Plasmid, Ribosome, Endospore, Inclusion bodies.
Unit-15: Bacterial Systematics: Eubacteria and Arachaebacteria – brief account of five kingdom and three domain classification, difference between Archaea and Bacteria.
Unit-16: Bacterial growth and Reproduction– binary fission and population growth, phase of bacterial growth, generation time, growth conditions – temperature, oxygen, water activity, pressure and pH.

Unit-17: Genetic Recombination in Bacteria-I: conjugation, 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: Importance and scope of microbiology, aquatic habitat, bio-geochemical cycles, plant-microbe Interaction – tumerogenesis and nitrogen fixation, microbial infection of man.
Unit-20: Applied Microbiology: Role of microbes in pharmaceutical industry, food industry and research.

Semester-II
Core Course-3 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-03, Course Title: Mycology and Phytopathology

Module-I: Mycology

Unit-1: Introduction of true Fungi: General characteristics. affinities with plants and animals, 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-2: Chytridiomycota and Zygomycota: General characteristics, habitat, economic importance, thallus organization, reproduction, life cycle (based on word diagram).
Unit-3: Ascomycota: general characters, habitat, economic importance, thallus organization, reproduction, types of fruit bodies. Classification and life cycle of Ascomycota.
Unit-4: Basidiomycota: general characters, economic importance, thallus organization, reproduction, types of fruit bodies, classification and life cycle. **Cultivation technique of mushroom** (in brief).
Unit-5: Deuteromycota: general characters, economic importance, thallus organization, reproduction, heterokaryosis and parasexuality, classification.
Unit-6: Myxomycota: present status, habitat, classification, vegetative body, fructification. **Oomycota:** present status, habitat, thallus organization, life cycle with reference to ***Phytophthora***.
Unit-7: Life cycle of ***Rhizopus*** and ***Penicillium***.
Unit-8: Life cycle of ***Agaricus*** *and* ***Helminthosporium***.
Unit-9: Lichen: habitat, types, vegetative and reproductive structures, specialized structures, economic and ecological importance. **Mycorrhiza**: types and their characteristics, economic importance.

Module-II: Phytopathology

Unit-10: Some relevant terms and their definitions.

Unit-11: General symptoms of plant diseases.
Unit-12: Spread of disease and physiological effects of pathogen.
Unit-13: Chemical and external features of infection.
Unit-14: Defence mechanism of plants.
Unit-15: Control of plant diseases.
Unit-16: Some common plant diseases.
Unit-17: Diagnoses of some diseases affecting Indian crops

Semester-II

Core Course-4 (Theory) Credit-6, Full Marks-70

Course Code: CC-BT-04, Course Title: Archegoniate (Bryophyte + Pteridophyte + Gymnosperm)

Unit-1: Bryophyta: Introduction, general characteristics. Modern classification of Bryophytes (Crandal- Stotler and Stotler2009) up to class.
Unit-2: General features, life cycle of ***Riccia*** , ***Marchantia, Porella, Anthoceros*** **and** ***Funaria*** (developmental stages not included).
Unit-3: Ecological and economic importance of Bryophytes with special reference to ***Sphagnum***.
Unit-4: Pteridophytes: general characteristics of Pteridophytes. Classification of Pteridophytes up to class (Sporne, 1975).
Unit-5: General features, life cycle of ***Psilotum, Lycopodium, Selaginella, Equisetum*** **and** ***Pteris*** (developmental stages not included).
Unit–6: General characters of ***Cooksonia***, ***Rhynia*** and ***Lepidodendron***.
Unit–7: Apogamy. Apospory, Heterospory and Seed habit. Origin and evolution of Pteridophytes. Telome concept and its significance. Steler evolution. Economic importance of Pteridophytes.
Unit-8: Characteristics of Gymnosperms and their classification.
Unit-9: 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.

Semester-III

Core Course-5 (Practical) Credit-6, Full Marks-70

Course Code: CC-BT-05, Course Title: Practical (Anatomy, Economic Botany; Morphology, Plant Systematics; Plant Ecology and Phytogeography)

Module-I: Anatomy

Unit-1: Identification of anatomical structures with reasons (from permanent slide). Parenchyma and Collenchyma.
Unit-2: Identification of anatomical structures with reasons (from permanent slide): Sclerenchyma.
Unit-3: Identification of anatomical structures with reasons (from permanent slide): Sclereids and Trachieds.
Unit-4: Identification of anatomical structures with reasons (from permanent slide): Trachea and Sieve Tube.
Unit-5: Identification of anatomical structures with reasons (from permanent slide): Different types of vascular bundles.

Unit-6: Identification of anatomical structures with reasons (from permanent slide): Different types of stomata.
Unit-7: Identification of anatomical structures with reasons (from permanent slide): Trichomes and Lenticel.
Unit-8: Study of secondary growth (permanent slides should be prepared by the students): ***Boerhavia*** and ***Bignonia*** stem.
Unit-9: Study of secondary growth (permanent slides should be prepared by the students): ***Dracaena*** stem and ***Tinospora*** root.
Unit-10: Ecological anatomy- Study of anatomical features of ***Hydrilla*** stem, ***Nymphaea*** petiole (hydrophytes), ***Nerium*** leaf (xeromorph) and ***Vanda*** root (epiphytes).

Module-II: Economic Botany

Unit-11: Beverages: Tea (plant specimen, tea leaves).
Unit-12: Essential oil-yielding plants: Habit sketch of ***Rosa***, ***Vetiveria*** (specimens/ photographs).
Unit-13: Essential oil-yielding plants: Habit sketch of ***Santalum*** and ***Eucalyptus*** (specimen/photographs).
Unit-14: Rubber: specimen, photograph/model of tapping, samples of rubber products.
Unit-15: Drug-yielding plants: Specimens of ***Digitalis***, ***Papaver*** and ***Cannabis***.
Module-III: Morphology
Unit-16: Study of cohesion and adhesion of stamen and carpel.
Unit-17: Types of inflorescences, placentation.
Module-IV: Plant Systematics
Unit-18: Taxonomic study of angiospermic plants : ***Brassica* sp**, ***Sida* sp**, ***Cassia* sp**, ***Coccinia cordifolia***.
Unit-19: Taxonomic study of angiospermic plants: ***Solanum* sp**, ***Leonurus sibiricus***, ***Leucus* sp**, ***Oldenlandia* sp**, ***Ixora* sp**.

Module-V: Plant Ecology and Phytogeography

Unit-20: Study of Community structure by quadrat method.
Unit-21: Preparation and submission of ten herbarium specimens of different taxa.
Unit-22: Determination of pH of various soil and water samples (pH meter, Universal indicator/ Lovibond comparator and pH paper).

Semester-III

Core Course-6 (Practical) Credit-6, Full Marks-70
Course Code: CC-BT-06, Course Title: Practical (Biomolecules and Plant Metabolism; Plant Physiology; Reproductive Biology of Angiosperms)

Module-I: Biomolecules and Plant Metabolism

Unit-1: Detection of organic acids: Citric and Tartaric.
Unit-2: Detection of organic acids: Oxalic and Malic.
Unit-3: Detection of titrable acidity from plant sample.
Unit-4: Detection of Carbohydrate from plant samples.
Unit-5: Detection of protein from plant samples.
Unit-6: Detection of Ca, Mg from plant sample.
Unit-7: Detection of Fe, and S from plant sample.

Unit-8: Estimation of dissolved oxygen content from water samples.
Unit-9: Estimation of catalase activity from plant materials by colorimetric method and amino nitrogen by titrimetric method.
Unit-10: To compare the rate of respiration in different parts of a plant.

Module-II: Plant Physiology

Unit-11: Preparation of solutions (% and Molar).
Unit-12: Demonstration of osmotic pressure by plasmolytic method using ***Rhoeo*** leaf.
Unit-13: Determination of osmotic pressure by gravimetric method using ***Rhoeo***/potato tuber.
Unit-14: Determination of rate of transpiration per unit area by weighing method.
Unit-15: Imbibition of water by dry seeds (starchy, proteinaceous and fatty seeds).
Unit-16: Determination of (%) seed viability by TTC (Triphenyl Tetrazolium Chloride) test.
Unit-17: Effect of CO_2 on photosynthesis using bicarbonate solutions.
Unit-18: Determination of rate of aerobic respiration using germinating seeds.
Unit-19: Comparison of the rate of transpiration (in upper and lower surface of leaf).
Unit-20: Determination of Q_{10} for imbibition of water using dry gram seeds.

Module-III: Reproductive Biology

Unit-21: Pollen grains: Fresh preparation and permanent slides showing ornamentation and apertures.
Unit-22: Study of pollinia from permanent slides.

Semester-III
Core Course-7 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-07, Course Title: Anatomy; Economic Botany

Module- I: Plant Anatomy

Unit-1: Plant cell wall.
Unit-2: Tissues types and functions.
Unit-3: Structures of root apex and shoot apex.
Unit-4: Mechanical tissues and their principles of distribution.
Unit-5: Types of stomata.
Unit-6: Stelar types and evolution.
Unit-7: Nodal anatomy.
Unit-8: Cambium-primary and secondary structures, nature and functions.
Unit-9: Secondary growth of stem.
Unit-10: Secondary growth of root.
Unit–11: Anomalous secondary growth (stem of ***Bignonia***, ***Boerhaavia***).
Unit-12: Anomalous secondary growth (stem of ***Dracaena*** and root of ***Tinospora***).
Unit-13: Anatomical adaptation of Xerophytes and Hydrophytes.

Module-II: Economic Botany

Unit-14: Concept of Centres of Origin, their importance with reference to Vavilov's work.

Unit-15: Economic plants – classification and uses.
Unit-16: Scientific name, family, parts used and uses of Maize, Mung, Ginger, Sugar cane, Mustard.
Unit-17: Scientific name, family, parts used and uses of Lemon grass, Coconut, Sal, Teak, Cotton.
Unit-18: Cultivation of Paddy, Wheat and Jute.
Unit-19: Cultivation of Tea and Coffee and their processing.
Unit-20: Pharmacognosy- definition, objectives and importance.
Unit-21: Scientific name, family, active principles and uses of the following medicinal plants: Ipecac,Kalmegh, Neem and Vasaka.

Semester-IV
Core Course-8 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-08, Course Title: Morphology; Plant Systematics

Module- I: Morphology

Unit-1: Inflorescence – different types with examples.
Unit-2: Flowers – types, aestivation, cohesion and adhesion of stamens.
Unit-3: Placentation, different types of ovules.
Unit-4: Fruits – types with examples.
Unit-5: Seed – types with examples.

Module-II: Plant Systematics

Unit-6: Taxonomy, Systematics, Classification, Identification and Nomenclature – terms and definitions only. Types of Classifications– Artificial, Natural and Phylogenetic, definitions and examples.
Unit-7: Nomenclature – elementary knowledge of ICN (ICBN) including important rules. Effective and Valid Publications. Rules of priority Author citation, Ranks and Names.
Unit-8: Broad features of the systems of classifications of Linnaeus (artificial).Bentham and Hooker (natural). Cronquist (phylogenetic). APG Classifications.
Unit-9: 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: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: 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.

Semester-IV
Core Course-9 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-09,
Course Title: Plant Physiology; Reproductive Biology of Angiosperms

Module-I: Plant physiology

Unit-1: Cell Physiology: Introduction, cell membrane, water potential and its component imbibition, diffusion, osmosis, plasmolysis, osmotic relation of a plant cell.
Unit-2: 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 by the land plants, factors affecting absorption of water.
Unit-3: Ascent of sap: introduction, different theories, experiments on conduction of water.
Unit-4: Transpiration: definition, types and sites of transpiration, mechanism of stomatal transpiration, factors affecting transpiration, anti-transpirations, guttation.
Unit-5: Mineral nutrition of plants: Introduction, essential and non-essential elements, criteria of essentiality of elements, general and specific rolls of macro- and micro-elements in plants, deficiency symptoms.
Unit-6: Translocation of solutes: definition, translocation of organic materials, direction and mechanism of phloem transport, translocation of inorganic materials.
Unit-7: Growth Physiology: definition of growth and development, sites of plant growth, phases of growth, factors affecting growth, measurement of growth.
Unit-8: Plant growth: Concept of plant growth regulators and phytohormones. Natural, synthetic and postulated hormones, physiological roles of Auxins, Gibberelins, Cytokinins, Ethylene and Abscisicacid. Biosynthesis and bioassay of Auxins and Gibberelins.
Unit-9: 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, law of limiting factors.
Unit-10: Respiration: types of Respiration, Glycolysis, Krebs cycle, ETS and Oxidative Phosphorylation, Pentose Phosphate Pathway, R.Q.
Unit-11: Photorespiration: definition, mechanism, differences between Respiration and Photorespiration, significance.
Unit-12: Nitrogen fixation: sources of nitrogen, biological nitrogen fixation, mechanism, nodulins, basic concept of *nif* and *nod* genes.
Unit-13: Plant movements: different types of movements, movements of curvature, tropic movements, nastic movements, nutation, turgour movements.
Unit-14: Physiology of flowering: Photoperiodism, critical day length, SDP, LDP, DNP, SLDP, and LSDP, site of perception of photoperiodic stimulus, vernalization and devernalization, role of phytochrome in flowing.
Unit-15: Seed physiology: definition of propagules, germination and dormancy of seeds, morphological and biochemical changes during seed germination, types, causes of methods of breaking seed dormancy.

Module-II: Reproductive Biology of Angiosperms

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

Semester-IV
Core Course-10 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-10, Course Title: Biomolecules and Plant Metabolism

Module-I: Biomolecules

Unit-1: Carbohydrates: Nomenclature and classification; Monosaccharides, Disaccharides; Oligosaccharides and Polysaccharides.
Unit-2: Lipids: Definition and major classes of storage and structural lipids; fatty acid structure and function essential fatty acids.
Unit-3: Triacylglycerols structure, function and properties; phosphoglycerides.
Unit-4: Proteins: structure of amino acids; levels of protein structure-primary, secondary, tertiary and quaternary.
Unit-5: Protein denaturation and biological roles of proteins.
Unit-6: Nucleic acids: structure of nitrogenous bases; structure and functions of nucleotides; types ofnucleic acids.
Unit-7: Structure of A, B and Z-types of DNA; Types of RNA, structure of t-RNA.
Unit-8: Bioenergetics: loss of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reaction, redox reaction.
Unit-9: ATP; structure and its role as an energy currency molecule.

Module-II: Plant Metabolism

Unit-10: Concept of metabolism.
Unit-11: Water, pH, buffer solutions.
Unit-12: Amino acids and primary structure of proteins.
Unit-13: General structure of amino acids, structure of twenty common amino acids.
Unit-14: Proteins – different structure levels of proteins, denaturation and biological roles of proteins.
Unit-15: Enzymes – properties, enzyme inhibition, allosteric enzyme.
Unit-16: Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzyme and prosthetic groups.
Unit-17: Classification of enzymes, according to IUB active site of enzyme, specification, mechanism of action (activation energy, lock and key hypothesis, induced – fit and acid base theory).

Unit-18: Michaelis – Menton equation, different types of enzyme inhibition and their effect on Vmax and Km, factors affecting enzyme activity.
Unit-19: Plant pigments: Introduction, plastidial and non-plastidial pigments.
Unit-20: Absorption of light energy by plant pigments, chemistry of chlorophylls and carotenoids.

Semester-V
Core Course-11 (Practical) Credit-6, Full Marks-70
Course Code: CC-BT-11, Course Title: Practical (Cell Biology; Plant Biotechnology; Genetics and Molecular Biology)

Module-I: Cell Biology

Unit-1: Study of mitotic chromosome: Metaphase chromosome preparation (Pre-treatment, Fixation Staining.
Unit-2: Temporary squash preparation of ***Allium cepa*** root tips.
Unit-3: Temporary squash preparation of ***Aloe*** root tips**.**
Unit-4: Determination of mitotic index and frequency of different mitotic stages in prefixed root tips of ***Allium cepa***.
Unit-5: Identification of different mitotic stages from permanent slides.
Unit-6: Temporary smear preparation from ***Allium*** flower buds for study of meiotic chromosome.
Unit-7: Temporary smear preparation from ***Rhoeo*** flower buds for study of meiotic chromosome.
Unit-8: Identification of different meiotic stages from permanent slides.

Module-II: Plant Biotechnology

Unit-9: Study of anther, embryo and endosperm culture.
Unit-10: Micropropagation, somatic embryogenesis and artificial seeds through photographs.
Unit-11: Study of steps of genetic engineering for production of Bt cotton through photographs.
Unit-12: Study of steps of genetic engineering for production of Golden rice through photographs.
Unit-13: Study of steps of genetic engineering for production of Flavr Savr tomato through photographs.

Module-III: Genetics and Molecular Biology

Unit-14: Determination of mean, standard deviation and standard error from samples. (leaflet size etc.).
Unit-15: Determination of Goodness of fit in normal and modified monohybrid ratios.
Unit-16: Determination of Goodness of fit in normal and modified dihybrid ratios.
Unit-17: Study of structures of prokaryotic RNA polymerase through photographs.
Unit-18: Study of structures of eukaryotic RNA polymerase II through photographs.
Unit-19: 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-20: Preparation of MS medium.

Semester-V
Core Course-12 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-12, Course Title: Genetics and Molecular Biology

Module- I: Genetics

Unit-1: Mendelian Genetics and its extensions. Mendel's Laws and Chromosome Theory of Inheritance; Gene Interactions; Complete Dominance, Incomplete Dominance and Co-dominance.
Unit-2: Multiple Alleles; Lethal Alleles; Allelic Complementation Test and Complementary Gene Action.
Unit-3: Epistasis – different types; Modifier and Suppressor Genes; Pleiotropy; Penetrance and Expressivity.
Unit-4: Environment and Gene Expression; Polygenic Inheritance.
Unit-5: 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-test cross; Interference and Coincidence; numerical based on Gene mapping; Sex-chromosomes and Sex-linkage.
Unit-6: 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 – kappa particles in ***Paramoecium***.
Unit-7: Eukaryotic Chromosome – structure and organization: Chromosome Number, Morphology, Nomenclature and Organization; Chromosome Banding, Chromosome Painting. **In-situ Hybridization**–FISH; Polytene chromosomes; Euchromatin, Heterochromatin – Constitutiveand Facultative.
Unit-8: Variation in Chromosome Number and Structure: Polyploidy and Aneuploidy; Deletion, Duplication, Inversion and Translocation; Position Effect.
Unit-9: Gene Mutation: Types and molecular basis of mutations; Mutagens; Detection of mutations –CIB method; DNA Repair Pathways.
Unit-10: Modern Concept of Gene and Genetic Code: One gene- One Polypeptide hypothesis; Central Dogma; Properties of genetic code and its decipherence.
Unit-11: Population and Evolutionary Genetics: Allele and Genotype frequencies; Hardy–Weinberg Law. Role of Natural Selection, Migration, Mutation and Genetic Drift; Genetic variation and Speciation.

Module- II: Molecular Biology

Unit-12: DNA – Genetic Material and Structure: DNA as genetic material – proof, types of DNA and genetic material; Denaturation, Renaturation and Cot Curves; Nucleosome Model.
Unit-13: DNA Replication: General principles – bi-directional, semi-conservative and semi discontinuous; RNA priming; models of DNA replication; enzymes involved in DNA replication.
Unit-14: Gene Expression and its Regulation: Transcription and its regulation in Prokaryotes and Eukaryotes; Eukaryotic RNA – split genes and splicing Mechanism; mRNA processing; RNA editing and mRNA transport. Translation – initiation, elongation and termination of polypeptides; inhibitors of protein synthesis; post-translational modification of proteins.
Unit-15: Transposable Elements and Plasmids: Transposable elements in Prokaryotes and Eukaryotes, their classification and properties. **Plasmids** – structure and properties; plasmid pBR 322 – salient features.

Unit-16: Restriction Endonuclease and Recombinant DNA Technology: Restriction enzymes – nomenclature, types and functions with examples.Gene Cloning – basic steps; Cloning Vectors – properties and types; shuttle vector and expression vector; Reporter Genes; Cloned Genesand Recombinant Proteins; Ethical and legal considerations.
Unit-17: Genomic Library and RFLP: Construction of Genomic, Chromosome and cDNA libraries; screening of DNA library; Genomics, Genome Sequences and their Annotation; Single Nucleotide Polymorphisms and Haplotypes. Future directions in Genomics; RFLPs and their uses.

Semester-VI
Core Course-13 (Theory) Credit-6, Full Marks-70
Course Code: CC-BT-13, Course Title: Plant Ecology and Phytogeography

Module I: Plant Ecology

Unit-1: Plant Ecology- definition, branches, relevance to human civilization.
Unit-2: Ecosystem- concept and types of ecosystem, components –biotic and abiotic, energy flow.
Unit-3: Nutrients cycling (carbon, nitrogen, phosphorous), biotic interrelationship.
Unit-4: Plant communities- definition, habitat and niche, ecotone and edge effects.
Unit-5: Community dynamics and plant succession types: primary and secondary successions.
Unit-6: Ecological factors: soil-origin, formation, composition, soil profile; water-state of water in the environment, precipitation types.
Unit-7: Light and temperature variation, optimal limiting factors.
Unit-8: Atmosphere and plant responses-I: Hydrophytes – Fresh water environments, Classification of hydrophytes and xerophytes.
Unit-9: Morphological, anatomical and physiological adaptations of Hydrophytes.
Unit-10: Atmosphere and plant responses-II: Psammophytes, Lithophytes, Psychrophytes, Succulents and their morphological adaptations.
Unit-11: Atmosphere and plant responses-III: Halophytes and their distributions, mangrove vegetation, ecological adaptations.
Unit-12: Environmental pollution: air pollution, water pollution and their impact on plants.
Unit-13: Global environmental issues: greenhouse gases, global warming, ozone depletion, acid rain and EL-Nino.

Module II: Phytogeography

Unit-14: Phytogeographical zones of India**.**
Unit-15: Endemism: definition, types, causes of endemism, endemic flora of India.
Unit-16: Flora of Eastern Himalaya.
Unit-17: Flora of western Himalaya.
Unit-18: Flora of Sundarbans.
Unit-19: Definition of Biodiversity, Biodiversity hotspots; rare and threatened plants of India; red data book.
Unit-20: Plant conservation: Significance of conservation, ex-situ and in-situ conservation; biosphere reserve; sanctuary; national park.

Semester-VI

Core Course-14 (Theory) Credit-6, Full Marks-70

Course Code: CC-BT-14, Course Title: Cell Biology; Plant Biotechnology

Module-I: Cell Biology

Unit-1: Microscopy**:** Light, Phase contrast, Flurosence and Electron microscopy; Confocal microscopy.
Unit-2: Eukaryotic Cell**:** Organization and functional structures and chemical components.
Unit-3: Nuclear organization**:** ultrastructure of nuclear envelope, structure and functions of Nucleus.
Unit-4: Structure and functions of Ribosome and Lysozomes.
Unit-5: Structures and functions of Mitochondria.
Unit-6: Structures and functions of chloroplasts.
Unit-7: Endomembrane system**,** general idea; endoplasmic reticulum: structure and function.
Unit-8: Golgi apparatus: organization and function.
Unit-9: Mitosis and Meiosis: Detail accounts of phases and events; Their significance.
Unit-10: Cell cycle and its control.

Module-II: Plant Biotechnology

Unit-11: Historical perspectives; composition of nutrients.
Unit-12: Inorganic, organic elements and plant growth regulators (role).
Unit-13: Sterilization; cellular totipotency.
Unit-14: Organogenesis, embryogenesis (somatic and zygotic), micropropagation.
Unit-15: Embryo culture and its application.
Unit-16: Protoplast culture and its application.
Unit-17: Cryopreservation and germplasm conservation.
Unit-18: Tissue culture in conservation of endangered plants.
Unit-19: Genetic Engineering and transgenic plants.
Unit-20: Electroporation, particle gun technologies, microinjection.
Unit-21: Application of biotechnology in agriculture, horticulture and forestry.

Discipline Specific Elective Courses

Semester-V
Discipline Specific Elective-1 (Theory) Credit-6, Full Marks-70
Course Code: DS-BT-11, Course Title: Stress Biology

Unit-1: Defining plant stress: Acclimation and adaptation.
Unit-2: Environmental factors: Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation insect and disease resistance by jasmonates.
Unit-3: Stress sensing mechanisms in plants: Calcium modulation, Phospholipid signaling.
Unit-4: Developmental and physiological mechanisms that protect plants against environmental stress: Adaptation in plants; Changes in root: shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production.

Semester-V
Discipline Specific Elective-2 (Practical) Credit-6, Full Marks-70
Course Code: DS-BT-21, Course Title: Practical (Stress Biology; Natural Resource Management; Plant Breeding)

Module-I: Stress Biology

Unit-1: Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
Unit-2: Superoxide activity in seedlings in the absence and presence of salt stress.
Unit-3: Quantitative estimation and zymographic analysis of catalase.
Unit-4. Quantitative estimation and zymographic analysis of glutathione reductase.

Module-II: Natural Resource Management

Unit-5: Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
Unit-6: Collection of data on forest cover of specific area.
Unit-7: Measurement of dominance of woody species by DBH (diameter at breast height) method.

Module-III: Plant Breeding

Unit-8: Calculation of mean, standard deviation and standard error.
Unit-9: Calculation of correlation coefficient values and finding out the probability.
Unit-10: Calculation of 'F' value and finding out the probability value for the F value.

Semester-VI
Discipline Specific Elective-3 (Theory) Credit-6, Full Marks-70
Course Code: DS-BT-31, Course Title: Plant Breeding

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

Unit 2: Methods of crop improvement: Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively plants – Procedure, advantages and limitations.
Unit 3: Quantitative inheritance: Concept, mechanism, examples of inheritance of Kernel colour wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.
Unit 4: Inbreeding depression and heterosis: History, genetic basis of inbreeding depression and heterosis; Applications.
Unit 5: Crop improvement and breeding: Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

Semester-VI

Discipline Specific Elective 4 (Theory) Credit-6, Full Marks-70
Course Code: DS-BT-41, Course Title: Natural Resource Management

Unit-1: Natural resources: Definition and types.
Unit-2: Sustainable utilization: Concept, approaches (economic, ecological and socio-cultural).
Unit-3: Land: Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.
Unit-4: Water: Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.
Unit-5: Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan.
Unit-6: Forests: Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.
Unit-7: National and international efforts in resource management and conservation

Skill Enhancement Courses

Semester-III
Skill Enhancement Course 1 (Theory) Credit-2, Full Marks-60
Course Code: SE-BT-11, Course Title: Medicinal Botany

Unit 1: History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e-tabiya, tumors treatments/therapy, polyherbal formulations.

Unit 2: Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered

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

Unit 3: Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany;

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

Semester-IV
Skill Enhancement Course 2 (Theory) Credit-2, Full Marks-60
Course Code: SE-BT-21, Course Title: Plant Diversity and Human Welfare

Unit 1: Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agro-biodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.

Unit 2: Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agro-biodiversity, Projected scenario for biodiversity loss, Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

Unit 3: Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, In situ and ex situ conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

Unit 4: Role of plants in relation to Human Welfare; a) Importance of forestry, their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.

Generic Elective Courses
(For Learners of Honours courses other than Botany)

Semester-I
Generic Elective Course-1 (Theory) Credit-6, Full Marks-70
Course Code: GE-BT-11, Course Title: Biodiversity (Microbes, Algae, Fungi and Archegoniate)

Unit-1: Microbes: Viruses – Discovery, general structure, Economic importance; Bacteria – Discovery, General characteristics and cell structure; Economic importance.
Unit-2: Algae: General characteristics; Range of thallus organization; Morphology and life-cycles of the following: ***Nostoc, Oedogonium, Polysiphonia***. Economic importance of algae.
Unit-3: Fungi: Introduction-General characteristics, range of thallus organization, life cycle of ***Penicillium, Agaricus*** (Basidiomycota); Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.
Unit-4: Introduction to Archegoniate: Unifying features of archegoniates.
Unit-5: Bryophytes: General characteristics, Range of thallus organization. Ecology and economic importance of bryophytes with special mention of ***Sphagnum***.
Unit-6: Pteridophytes: General characteristics, Early land plants (***Cooksonia*** and ***Rhynia***). Ecological and economical importance of Pteridophytes.
Unit-7: Gymnosperms: General characteristics; morphology of ***Cycas*** and ***Pinus*** (Developmental details not to be included). Ecological and economical importance.

Semester-II
Generic Elective Course-2 (Theory) Credit-6, Full Marks-70
Course Code: GE-BT-21, Course Title: Plant Ecology and Taxonomy

Unit-1: Introduction to ecology.
Unit-2: Ecological factors: Brief knowledge about soil, water, light and temperature. Adaptations of hydrophytes and xerophytes.
Unit-3: Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types.
Unit 4: Ecosystem: Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous.
Unit-5: Phytogeography: Principle biogeographical zones; Endemism.
Unit-6: Introduction to plant taxonomy: Identification, Classification, Nomenclature.
Unit-7: Identification: Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.
Unit-8: Taxonomic evidences from palynology and cytology.
Unit-9: Taxonomic hierarchy: Ranks, categories and taxonomic groups
Unit-10: Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.
Unit-11: Types of classification- artificial, natural and phylogenetic. Bentham and Hooker (up to series).

Semester-III

Generic Elective Course-3 (Theory) Credit-6, Full Marks-70

Course Code: GE-BT-31, Course Title: Plant Anatomy and Embryology

Unit 1: Meristematic and permanent tissues: Root and shoot apical meristems; Simple and complex tissues.
Unit 2: Organs: Structure of dicot and monocot root stem and leaf.
Unit 3: Secondary Growth: Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).
Unit 4: Adaptive and protective systems: Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.
Unit 5: Structural organization of flower: Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.
Unit 6: Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization; Seed structure appendages and dispersal mechanisms.
Unit 7: Embryo and endosperm : Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship.
Unit 8: Apomixis and Polyembryony: Definition, types, and Practical applications.

Semester-IV

Generic Elective Course-4 (Theory) Credit-6, Full Marks-70

Course Code: GE-BT-41, Course Title: Economic Botany and Plant Biotechnology

Unit-1: Origin of Cultivated Plants: Concept of centres of origin, their importance with reference to Vavilov's work.
Unit-2: Cereals: Wheat- Origin, morphology, uses.
Unit 3: Legumes: General account with special reference to Gram and soybean.
Unit-4: Spices: General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses).
Unit-5: Beverages: Tea (morphology, processing, uses).
Unit-6: Oils and Fats: General description with special reference to groundnut.
Unit-7: Fibre Yielding Plants: General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)
Unit-8: Introduction to biotechnology
Unit-9: Plant tissue culture: Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications.
Unit-10: Recombinant DNA Techniques: Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR.

Suggested Readings

- College Botany (Vol. I) : Gangulee H. C., Das K. S, Datta C. T. (New Central BookAgency).
- College Botany (Vol. II) : Gangulee H. C. & Kar A. K. (New Central Book Agency).
- College Botany (Vol. III) : Mukherjee S (New Central Book Agency).
- Studies in Botany (Vol. I) : Mitra J. N., Mitra D & Chaudhuri S. K. (Moulik Library).
- Studies in Botany (Vol. II) : Mitra D, Guha J., Chaudhuri S. K. (Moulik Library).
- A Text Book of Biotechnology : Dubey R. C. (S. Chand & Co.).
- Molecular Biology and Biotechnology : Kumar H. D. (Vikash Publication).
- Text Book of Algae : Sharma O. P. (Tata Mc Graw Hill).
- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
- Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- A Text Book of Fungi : Chopra G. L. and Verma V. (Pradeep Publication).
- An introduction of Fungi : Dubey H. C. (Vikas Publishing House).
- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
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- Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8thedition.
- Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA,U.S.A.
- Singh, G. (2012). *Plant Systematics:* Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
- Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.

- Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA. · Taiz, L., Zeiger, E., (2010).
- Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
- Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers IndiaLtd., New Delhi. 4th edition.
- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
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