Syllabi and Courses of Study

for

Post-graduate Programme in Botany

UNIVERSITY OF KASHMIR, SRINAGAR

The revised syllabi and courses of study for Post-graduate programme in Botany is to be adopted for all the semesters from the Academic session 2012 onwards.

Course Structure: There will be 26 courses (20 theory and 6 lab.) in all. Theory papers will be named as Bot-01 to Bot-20 and Lab courses will be named as L-1 to L-6. Courses Bot-01 to Bot-05 and L-1 will form a part of M.Sc 1st Semester and Courses Bot-06 to Bot-10 and L-2 will form part of 2nd Semester, Bot-11 to Bot-15 and L-3, L-4 form part of 3rd Semester and Bot-16 to Bot-20 and L-5, L-6 will form part of M.Sc 4th Semester Curriculum. Courses Bot-01 to Bot-14 and Bot-16 to Bot-19 will form core courses along with L-1, L-2, L-3 and L-5 . Course Bot-15 and Bot-20 will constitute the optional courses along with their respective Lab. Courses, namely L-4 and L-6. Each theory course will be worth 3 credits and each practical worth 9 credits so that total course of M. Sc Botany is comprised of 114 credits. Each course will be of 100 marks and 2½ hrs duration while as lab courses L-1 to L-3 and L-5 will be of 100 marks and 8hrs duration whereas as L-4 and L-6 will be of 50 marks and 3hrs duration. 20% marks in each course (theory and practicals) are for internal assessment and 80 % for external examination. Internal assessment of theory papers will be based on quiz tests, assignments, seminars, tutorials etc. The internal assessment in respect of laboratory courses will be based on the conduct of practicals by a student and their evaluation by the concerned teacher(s) on a day-today basis. The students will be required to submit their lab. work records at the time of practical examination for evaluation by the examiner.

Botanical Trips: To make on-field observations and impart on-site training in the subject botany, the Department will ensure that a minimum of one field trip is organized during each semester to acquaint the students with the flora of the region and also to collect and prepare 50 plant specimens following standard herbarium techniques. The students will, however, avoid collection of rare and threatened plant species. The herbarium will have to be submitted at the time of practical examination.

Semester-wise course structure and break-up of marks

CORE COURSES

S. No./ Semester	Course code	Course Title	MARKS			
Semester-I			THEORY/LAB COURSE			
			EXTERNAL		INTERNAL	
			Max.	Min.	Max.	Min.
01	Bot-01	Viruses, Bacteria, Fungi & Plant Pathology	80	32	20	08
02	Bot-02	Algae, Bryophyta & Pteridophyta	80	32	20	08
03	Bot-03	Biology & Diversity of Gymnosperms	80	32	20	08
04	Bot-04	Plant Taxonomy	80	32	20	08
05	Bot-05	Plant Resource Utilization	80	32	20	08
06	L-01	Lab course	80	32	20	08
Semester-II						
07	Bot-06	Biodiversity and Conservation Biology	80	32	20	08
08	Bot-07	Development in Angiosperms	80	32	20	08
09	Bot-08	Reproductive Biology of Angiosperms	80	32	20	08
10	Bot-09	Cell and Molecular Biology	80	32	20	08
11	Bot-10	Population and Community Ecology	80	32	20	08
12	L-02	Lab Course	80	32	20	08
Semester-III						
13	Bot-11	Cytogenetics and Genetics	80	32	20	08
14	Bot-12	Molecular Genetics	80	32	20	08
15	Bot-13	Plant Biochemistry	80	32	20	08
16	Bot-14	Ecosystem Ecology	80	32	20	08
17	Bot-15	Optional Course	80	32	20	08
18	L-03	Lab Course	80	32	20	08
19	L-04	Lab Course	40	16	10	04
Semester-IV						
20	Bot-16	Plant Physiology	80	32	20	08
21	Bot-17	Genetic Engineering of Plants and Microbes	80	32	20	08
22	Bot-18	Plant, Cell, Tissue and Organ Culture	80	32	20	08
23	Bot-19	Biostatistics & Biotechniques	80	32	20	08
24	Bot-20	Optional Course	80	32	20	08
25	L-05	Lab Course	80	32	20	08
26	L-06	Lab Course	40	16	10	04

OPTIONAL COURSES

S. No.	Sub. code	Subject Name	MARKS			
Optional courses of Bot-15			THEORY			
			EXTERNAL		INTERNAL	
			Max.	Min.	Max.	Min.
27	Bot-15	Molecular Ecology-I	80	32	20	08
		Economic Botany & Reproductive Biology-I	80	32	20	08
		Crop Physiology-I	80	32	20	08
		Plant Pathology-I	80	32	20	08
		Crop Genetics & Molecular Breeding -I	80	32	20	08
		Plant Systematics and Diversity-I	80	32	20	08
Optional Courses of Bot-20						
28	Bot-20	Molecular Ecology-II	80	32	20	08
		Economic Botany & Reproductive Biology-II	80	32	20	08
		Crop Physiology-II	80	32	20	08
		Plant Pathology-II	80	32	20	08
		Crop Genetics& Molecular Breeding -II	80	32	20	08
		Plant Systematics and Diversity-II	80	32	20	08

INSTRUCTIONS FOR PAPER SETTERS

Each theory paper will be of 80 marks and 2½ hrs duration while as lab courses L-1 to L-3 and L-5 will be of 80 marks and 8hrs duration whereas as L-4 and L-6 will be of 40 marks and 3hrs duration.

Section A: It will include one question consisting of very short answer type eight parts, each part to be answered in about 20 words. Two parts will be set each section. The candidate will be required to attempt all the questions. Weightage shall be 20% of total marks.

Section B. It will consist of four short answer type questions, each to be answered in about 250 words. One question will be set from each unit and the candidate shall be required to attempt all the questions. Weightage shall be 40% of total marks.

Section C: It will consist of four long type questions, each to be answered in about 500 words. One question will be set from each unit and the candidate shall be required to attempt any two questions. Weightage shall be 40% of total marks.

University of Kashmir, Srinagar

Model Question Paper

Subject: Botany **Max. Marks: 80**
Course No. Bot. **Minimum Pass Marks: 32**
Course Title: ABC **Time allowed: 2½ hrs**

Note: Attempt all questions from Sections A and B, and only two questions from Section C.

Section A

(Very short answer type questions, each to be answered in 10-20 words)

Q. No.1. **(8×2=16)**

i) Differentiate between parasitism and parasitoidism.
ii) What do you understand by niche-overlap?
iii) What are the two components of species diversity?
iv) How are characteristics of regular Markov chain processes related to ecological succession?
v) Define ecotone.
vi) What are the basic tenets of resource-ratio hypothesis of ecological succession?
vii) List the synthetic characteristics of a community.
viii) Enumerate the traits of invasive plant species?

Section B

(Short answer type questions, each to be answered in 200-250 words)
(4×8=32)

Q. No.2. Bring out the relationship between disturbance and species diversity.

Q.No.3. What are the changes that take place in community energetics during the course of ecosystem development?

Q.No.4. Give a brief account of predation, spatial heterogeneity and climate stability theories of latitudinal species diversity gradient.

Q.No.5. Give a concise account of self-thinning in plant populations.

Section C

(Long answer type questions. Each of the any two questions to be answered in about 400-500 words) (2×16=32)

Q.No.6. Discuss in detail the geometric, exponential and logistic models of population growth and also bring out the assumptions of each model.

Q.No.7. Give a critical account of the statistical and biological models of species abundance distribution.

Q.No.8. Describe the salient features of Climax-pattern hypothesis of climax community characterization and also point out its advantages over the Monoclimax theory of Clements.

Q.No.9. How does equilibrium model of island biogeography proposed by MacArthur and Wilson (1963) explain species turnover on islands?

Semester-I

BOT-01: VIRUSES, BACTERIA, FUNGI AND PLANT PATHOLOGY

Unit I

Eubacteria: origin and evolution, diversity assessment and classification criteria; bacterial growth and nutrition, ultra-structural details; types of reproduction; ecological and economic importance.

Archaebacteria: general account, major groups of archaebacteria (methanogens, extreme halophiles, extreme thermophiles); structural variations (comparison with eubacteria and eukaryotes); evolutionary significance.

Cyanobacteria: salient features, cyanobacterial symbioses, endosymbiotic evolution, biological and ecological importance.

Unit II

Viruses: general characteristics, origin of viruses; chemical nature and ultra-structure.

Replication and isolation: replication (mechanisms of viral replication; differences between DNA and RNA viruses); transmission (ways and vectors); isolation and purification.

Virus-like agents: virions, viroids and prions- concept, structural aspects and evolutionary importance; economic importance of viruses.

Unit III

Fungi: general characters of fungi, cell ultra-structure; unicellular organization; cell wall composition; nutrition (saprobic, biotropic); reproduction (vegetative, asexual, and sexual); heterothallism; heterokaryosis; parasexuality; recent trends in classification of fungi; structural diversity and modes of reproduction in Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina; Role of fungi in industry with reference to food and medicine; mycorrhizae- types and role

Unit IV

Plant Pathology— introduction to plant pathology, definition of terms used in plant pathology; plant diseases: concept, nature and classification of plant diseases.

Symptoms, etiology, epidemiology and control of following plant diseases: paddy blast, powdery mildew of cucurbits, black stem rust of wheat, apple scab, peach leaf curl, damping off seedlings, black rot of crucifers, angular leaf spot of cotton.

Phytoplasma: general characteristics and role in causing plant diseases; use of fungi as biocontrol agents

BOT-02: ALGAE, BRYOPHYTA AND PTERIDOPHYTA

Unit I

Algae: Algae in diverse habitats (terrestrial, freshwater, marine); thallus organisation; evolutionary relationships; cell ultrastructure; reproduction (vegetative, asexual, sexual); criteria for classification of algae (pigments, reserve food, flagella); classification and salient features of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

Unit II

Bryophyta: distribution, classification, morphology, structure and reproduction of Takakiales; Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales, and Polytrichales, evolution of gametophyte in Bryophytes.

Unit III

Pteridophyta: morphology, anatomy, reproduction and classification of Psilopsida (Psilotales), Lycopsida (Lycopodiales, Isoetales and Selaginellales) Sphenopsida (Equisetales) and Pteropsida: Primofilices (Cladoxylales), Eusporangiatae (Marattiales), Osmundidae (Osmundales), Leptosporangiatae (Marsileales and Salviniales).

Unit-IV

Algal blooms and role of phycoviruses in their control; algal food, biofertilizers and source of phycocolloids, aligns, carrageenans, and agar agar; economic and ecological importance of bryophytes; evolution of stele, heterospory and origin of seed habit in pteridophytes.

BOT-03: BIOLOGY AND DIVERSITY OF GYMNOSPERMS

UNIT I

Classification of gymnosperms
Diversity and distribution of gymnosperms in India
Evolution of gymnosperms
Gymnosperms as probable ancestors of angiosperms
Economic importance of gymnosperms

UNIT II

Fossil gymnosperms: general account of:

Pteridospermales(Lyginopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae)
Cycadeoidales
Cordiatales

UNIT III

General account, structure and reproduction in:

Cycadales
Ginkgoales
Coniferales

UNIT IV

General account, structure and reproduction in:

Taxales
Ephedrales
Welwitschiales
Gnetales

BOT-04: PLANT TAXONOMY

Unit-I

Need for taxonomy: taxonomy, systematics, classification and phylogeny; contributions of taxonomy to biology; relevance of taxonomy to human society.

Plant classification: a historical account; phenetics (principles, selection of characters, character x taxon matrix, similarity matrix, phenogram construction); cladistics (concept, terminology, taxon and character selection, character analysis, cladogram construction); relative merits and demerits of phenetics and cladistics.

Unit II

Taxonomic categories and characters: structure of taxonomic hierarchy; concept of taxonomic categories (supra-specific, species, and infra-specific); taxonomic characters (kinds and criteria).
Taxonomic sources: role of morphology, palynology, cytology, phytochemistry, and molecular biology in plant taxonomy

Unit III

Taxonomic tools and institutions: herbarium (procedures and roles); botanic garden (concept and roles); taxonomic literature (flora, monograph, revision, manuals, indices, journals); Botanical Survey of India (organization and role).
Plant identification: methods of identification; types of keys (dichotomous keys - kinds and construction, polyclaves - a brief account); role of information technology in plant identification.

Unit IV

Nomenclature: an overview of nomenclature codes (Viral, Bacteriological, Botanical, Cultivated Plants); principles of ICBN; type method (concept and kinds); author citation; effective and valid publication; synonymy.

Plant diversity in Kashmir Himalaya: a historical perspective of plant exploration; current status and utilization of plant resources

BOT-05: PLANT RESOURCE UTILIZATION

Unit I

Plant Biodiversity: concept, utilization and concerns
Origin of Agriculture: time and place of origin, archaeological and other evidences
World Centres of origin and domestication of cultivated plants: Vavilov's and de Candolle's concept, Centres and non-centres, secondary centres, plant introduction
Green revolution: concept, concerns, benefits and adverse consequences.

Unit II

Origin, evolution, domestication and uses of:
Food plants- maize
Fodder- alfalfa

Fibre plants- jute
Oil yielding plants- mustard and groundnut
Spices- saffron

Unit III

Agricultural innovation for meeting food demands: agricultural bio-technology, synthetic crops, agriculture in arid zones.
Medicinal and aromatic plants: botany, chemical composition (active principal), chemistry of action, use and misuse of species of *Aconitum, Dioscorea , Saussurea, Cymbopogon, Mentha*, and *Lavendula.*
Psychoactive drugs: sources, chemistry of action, use and misuse of *Papaver somniferum* and *Cannabis sativa*

Unit IV

Paper making: sources of raw material and processing of paper
General account of NWFP's: paper, gums, resins, tannins, dyes, bamboo, rattans .
Rosaceous fruits of Kashmir: general account, botany and uses with special reference to apple, pear, plum, cherry, almond and apricot.

L-01 (Lab. Course) Based on Courses Bot. 01 to Bot. 05

1. Learning methods of sterilization and techniques of inoculation.
2. Preparation of culture media and aseptic transfer of pure cultures.
3. Differential staining of microorganisms to study their morphology and staining reactions.
4. Demonstration of the presence of nitrogen fixing organisms (*Rhizobium* sp.) in root nodules of legumes.
5. Morphological study and identification of the following representative members of fungi: *Perenospora, Albugo, Mucor, Rhizopus, Ustilago, Polyporus, Morchella, Sacharomyces, Aspergillus, Penicillium, Alternaria, Clletotrichum and Fusarium*
6. Preparation of fungal cultures of *Rhizopus, Mucor, Aspergillus, Penicillium, Trichoderma, Alternaria,Verticillium*
7. Sterilization methods (physical and radiation), Preparation of media (PDA, Soil extract Agar, Richards solution, peptone dextrose agar medium.
8. Symptomology and studies of some diseases of Plants: White rust, downy mildew, Powdery mildew, rusts, smuts, wilts, rice blast, apple scab, citrus canker, peach leaf curl, tomato mosaic virus, cauliflower mosaic virus.

9. Morphological study of the representative members of Algae: *Anabaena, Nostoc, Pediastrum, Volvox, Hydrodictyon, Ulva, Clostridium, Chara, Botrydium, Enteromorpha, Padina, Bulbochaete, Ceramium* and *Batrachospermum*.
10. Study of morphological, anatomical and reproductive structures of various bryophytes viz: *Pellia, Porella, Anthoceros, Polytrichum, Andreaea, Bryum, Mnium* and *Funaria*.
11. Study of morphological, anantomical and reproductive structures of the representative Pteridophytes viz: *Psilotum, Ophioglossum, Dryopteris, Equistem, Marsilea* and *Pteris*.
12. Study of important fossil Pteridophytes from prepared slides.
13. Study of morphological, anatomical and reproductive structures of representative Gymnosperms, such as *Pinus, Cedrus, Abies, Picea, Taxus, Cephalotaxus, Araucaria, Taxodium, Gnetum, Ephedra, Ginkgo, Cycas*.
14. Collection, description and herbarium preparation of various types of leaves, inflorescences and fruits.
15. Preparation of character x taxon matrix.
16. Construction of dichotomous taxonomic keys (indented, parallel and serial).
17. Taxonomic description of representative families (Ranunculaceae, Rosaceae, Asteraceae, Brassicaceae, Fabaceae, Lamiaceae, Apiaceae, Solanaceae, Caryophylaceae, Malvaceae, Poaceae, Liliaceae).
18. Field trips for collection of plant specimens and preparation of general herbarium with field notes.
19. Microchemical tests for food reserves in cereals, millets and pulses
20. To study the morphology of the part used of various representative crops like rice, wheat, maize, potato, pulses and fruits
21. Study of viability of various crop seeds using germination and T.Z Test
22. Study of seed vigour using standard methods
23. Study of source spice and condiments (source, part used, active components)
24. Study of any five important fodder and forage crops
25. Study of various types of fibres viz. cotton. coir, hemp etc.
26. Morphology , microscospic study of oil yielding tissues and test for oil (mustard, groundnut, soybean, linseed, coconut, sunflower, castor, sesame and cashew nut)
27. Study of ethnobotanical aspects of various local products.

Semester-II

BOT-06: BIODIVERSITY AND CONSERVATION BIOLOGY

Unit I

Fundamentals of biodiversity: concept of biodiversity (a historical account); magnitude of global biodiversity (an overview); components of biodiversity (species richness and evenness); levels of biodiversity – organizational (genetic, species and ecosystem), spatial (alpha, beta and gamma); agro-biodiversity (concept and importance).

Unit II

Conservation biology: principles and characteristics; genetic variation (magnitude, loss and consequences); species extinction (concept and causes - ultimate and proximate); estimation of extinction rates (methods and their limitations); the IUCN scheme of threatened categories, summary of latest IUCN Redlist; ecosystems at risk (tropical rain forests, wetlands, mangroves and coral reefs).

Unit III

Conservation strategies: *in-situ* conservation strategies (concept of protected areas network); IUCN's PA management categories; an outline of National Parks, Wildlife Sanctuaries and Biosphere Reserves in India; concept and role of genetic reserves; *ex situ* conservation strategies (botanical gardens, field gene banks, seed banks, *in vitro* repositories, cryobanks, DNA banks); biodiversity hotspots (criteria, distribution and conservation implications).

Unit IV

Values of biodiversity and conservation efforts: values of biodiversity (direct use, indirect use, option and existence values); bioprospecting (concept and scope); general account of international conservation efforts (global organizations and conventions); general account of Indian conservation efforts (legislations and policies); non-formal conservation efforts.

BOT-07: DEVELOPMENT IN ANGIOSPERMS

Unit I

Seed germination and seedling growth: types of seed germination, metabolism and mobilization of carbohydrates, proteins and lipids; tropisms, hormonal control of seedling growth; some examples of genetic control of seed germination and seedling development.

Unit II

Root development: organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots, root hairs.

Leaf growth and differentiation: determination; phyllotaxy; control of leaf form; differentiation of epidermis with special reference to stomata**,** trichomes, and mesophyll

Unit III

Shoot development: organization of the shoot apical meristem (SAM); cytologicaland molecular analysis of SAM; mechanisms of cell division and cell to cell communication; tissue differentiation with reference to xylem and phloem; secretary structures and laticifers; wood development in relation to environmental factors.

Unit IV

Senescence and programmed cell death (PCD): concept, types of cell death, mechanism of PCD. PCD in the life cycle of plants, metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence.

BOT-08: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Unit I

Reproduction: vegetative and sexual reproduction; apomixis - mechanism, types and genetic basis ; flower development- induction and evocation, floral organ development, flowering in perennials-juvenility, seasonal flowering limiting duration of flowering, polycarpy and biennial bearing; role of microRNAs in flower development.

Unit II

Male and female gametophyte: structure of anther, role of tapetum, microsporogenesis- signalling pathways and transcriptional control, regulation of asymmetric first pollen mitosis, control of second pollen mitosis and sperm cell differentiation; female gametophyte development- initiation, development and genes involved; patterning, cell fate specification and maintenance of cell identities of female gametophyte.

Unit III

Pollination, pollen-pistil interactions and fertilization: pollination mechanisms, pollination syndromes, structure of pistil, pollen germination and compatible pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical, and molecular aspects);pollen tube growth and guidance, double fertilization

Unit IV

Seed development, fruit growth and dormancy: endosperm development, embryogenesis- landmarks of embryo pattern formation, regulation of embryo pattern formation, polyembryony; dynamics of fruit growth, biochemistry and molecular biology of fruit maturation; importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

BOT-09: CELL AND MOLECULAR BIOLOGY

Unit I

Cell wall and plasma membrane – structure and functions; membrane proteins – integral and transmembrane proteins.
The cytoskeleton: organization and role of microtubules and microfilaments, motor proteins.
Nucleus – Nuclear membrane and nuclear pore complex, transport of proteins and RNAs across nuclear membrane.

Unit II

Chloroplasts and mitochondria: genome organization, protein import, endo-symbiotic origin.

Golgi complex and ER: role in protein sorting and transport, Lysosomes – endocytosis and phagocytosis.
The cell cycle: phases of cell cycle, regulation of cell cycle progression, role of cyclin and cyclin-dependent kinases.

Unit III

DNA: DNA structure, DNA polymerases, replication apparatus, mechanism of DNA replication.
Transcription: RNA polymerase, concept of promoters, introns and their significance, transcription factors, mechanism of transcription, major differences between prokaryotes and eukaryotes (at transcriptional level).
RNA processing - Post transcriptional modifications, RNA editing.

Unit IV

Ribosomes - structure and assembly, tRNA and genetic code
Translation: Mechanism of protein synthesis, initiation, elongation and termination factors, major differences between prokaryotes and eukaryotes (at translational level).
Regulation of gene expression in prokaryotes (Lac operon, tryptophan operon) and eukaryotes (role of promoters, activators, repressors and DNA methylation).

BOT-10: POPULATION AND COMMUNITY ECOLOGY

Unit I

Population ecology: population characteristics; growth (geometric, exponential, logistic); dynamics (flux, self thinning) and regulation; population interactions- negative (inter-specific competition, parasitism, predation, herbivory), and positive (mutualism); ecological niche- definition and concept, niche parameters (niche width, overlap and complementarity), character displacement.

Unit II

Community ecology: community concept, characteristics (analytic and synthetic) and structure, guilds; species diversity- richness and evenness components; species abundance distribution, diversity patterns (latitudinal gradient- contributory factors and explanatory theories)

Unit III

Community development: temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic

composition; facilitation, tolerance and inhibition models, resource ratio hypothesis); changes in ecosystem properties, concept of climax and its characterization.

Unit IV

Community stability and island biogeography: MacArthur and Wilson's island biogeography equilibrium theory- limitations and modifications; colonization vs. extinction; species area relationship; diversity- disturbance, and diversity stability relationships; ecology of plant invasion- process of invasion, traits of invasive species, factors promoting community invasibility, impact of invasive species. Biomes: types (terrestrial and aquatic), distribution and unique features.

L-02 (Lab. Course) Based on Courses Bot. 06 to Bot. 10

1. Semi –pharmacognostic study of various threatened medicinal plants
2. To prepare an inventory of MAPs (Medicinal and Aromatic plants) in KUBG.
3. Measurement of various biodiversity indices (species diversity, species evenness, similarity index).
4. Field demonstration of GPS (Global Positioning System) and its utility in biodiversity studies.
5. Study of various economically and ethno-botanically important plants of Kashmir Himalaya
6. Field study of various threatened endemic plants of Kashmir Himalaya.
7. Field demonstration of *in situ* and *ex situ* conservation strategies through visit to the national parks, sanctuaries, botanical garden, herbaria, zoos, museums.
8. Study of living shoot apex of *Hydrilla*
9. Study of cytological zonation in the shoot apical meristem in double stained permanent slides of any suitable plant.
10. Study of different leaf arrangements
11. Study of C. S. of typical dicot and monocot leaves
12. Study of epidermal peels of leaves of appropriate to study various stomatal types
13. Study of anatomy of dicot and monoct roots and stems using appropriate materials
14. Study of microsporogenesis and gametogenesis in appropriate materials
15. Estimation of pollen germination and average pollen tube length *in vitro*
16. Study of different types of ovules, embryo sacs through examination of permanent slides
17. Isolation of monocot and dicot embryos from suitable materials
18. Demonstration of cell cycle, mitosis and meiosis.
19. Identification of different stages of mitosis and meiosis from temporary and permanent slides.
20. Study of morphology of metaphase chromosomes from onion root meristems.

21. Identification of different stages of meiosis from suitable plant material.
22. Study of various cell organelles using prepared slides and models
23. Cell wall staining with calcoflour
24. Silver banding for staining nucleolus-organizing region
25. Preparation of various types of stains for chromosome analysis.
26. Demonstration of microscopes (Simple compound microscope, phase contrast, fluorescence, SEM)
27. Types of quadrats (sampling units) and their utility.
28. Determination of minimum size and number of quadrats for phytosociological studies.
29. Computation of Frequency, Density, Abundance and Cover of constituent species of different communities.
30. Computation of Relative Frequency, Relative Density, Relative Abundance and Relative Cover of constituent species of different communities.
31. Estimation of IVI of the species in different communities.
32. Estimation of species diversity and dominance.
33. Comparison between protected and unprotected grasslands using community co-efficient

Semester-III

BOT-11: CYTOGENETICS AND GENETICS

Unit I

Chromosomes: chromosome structure, chromatin organization, nuclear DNA content and c-Value paradox, repetitive DNA - types and utility.
Molecular organization of centromere and telomere; euchromatin and heterochromatin; chromosome banding techniques (C, G and N) and their utility, concept and examples of split genes, overlapping genes and pseudo genes.

Unit II

Karyotype - concept and evolution; B chromosomes – characteristics and distribution
Structural heterozygotes: origin, meiosis and breeding behavior of deletion, duplication, inversion and translocation heterozygotes, Robertsonian translocation, B-A translocation.

Unit III

Euploidy: origin, meiosis and breeding behavior of haploids and autopolyploids, chromosome and chromatid segregation; role in crop improvement, origin and production of allopolyploids, role of allopolyploidy in evolution of major crop plants.
Aneuploidy: types, origin, meiosis and breeding behaviour, transmission of monosomics and trisomics and their role in chromosome mapping.

Unit IV

Alien gene transfer: methods of production of alien addition and substitution lines; transfer of individual chromosome (wheat and *Brassica*) and chromosome segments, utility of alien addition and substitution lines.
Flow cytometry (concept and utility), population genetics- the Hardy - Weinberg law, factors affecting Hardy Weinberg equilibrium (selection, mutation, migration and genetic drift).

BOT-12: MOLECULAR GENETICS

Unit I

Concept of gene and allele, Cis-Trans / complementation test, genetic fine structure (r-II locus), cistron, muton and recon.

DNA recombination mechanisms, molecular mechanism of recombination (role of Rec A, BCD enzymes), site specific recombination, gene conversion, multigene families and their evolution.

Unit II

Mutations: spontaneous and induced mutations; molecular basis of gene mutation; Missense mutations, nonsense mutations, frameshift mutations and silent mutations; transposable elements in prokaryotes and eukaryotes (examples from bacteria and maize), transposon induced mutations.
Types of DNA damage and repair mechanisms, Site-directed mutagenesis; concept of proto-oncogenes and oncogenes.

Unit III

Genetics of prokaryotes: Lytic asnd lysogenic cycles in phages, phage phenotypes, genetic recombination in phages.
Recombination in bacteria, genetic transformation, conjugation and transduction and their role in mapping of bacterial genes, plasmids – general properties and regulation of replication (control of copy number).

Unit IV

Chromosome mapping in eukaryotes: Genetic and physical mapping of genes/chromosomes, restriction mapping- concept and applicability.
In situ hybridization techniques (FISH, McFISH, GISH and Fibre FISH), Somatic cell hybridization and hybridoma technology (concept and utility).

BOT-13: PLANT BIOCHEMISTRY

Unit I

Principles of bioenergetics: bioenergenetics and thermodynamics; concept of free energy; biological oxidation-reduction reactions- redox potential and free energy; phosphoryl group transfer and ATP.
Enzymes: kinetics of single-substrate enzyme catalyzed reactions- Michaelis-Menton equation and its significance; enzyme inhibition; isozymes (brief account)

Unit II

Nitrogen and sulphur metabolism: nitrogen in environment; mechanism of nitrate uptake and assimilation; ammonium assimilation; biological nitrogen fixation; nodule formation and nod factors; the photorespiratory nitrogen cycle; sulphur uptake, transport and assimilation.

Unit III

Respiration and lipid metabolism: glycolysis and citric acid cycle (overview and unique features in plants); pentose phosphate pathway; electron transport system; synthesis and release of ATP; alternative oxidase system; cyanide resistant respiration; classification of lipids; fatty acid biosynthesis; oxidation of saturated and unsaturated fatty acids; glyoxylate cycle.

Unit IV

Photochemistry and photosynthesis: photosynthesis from historical perspective; photosynthetic pigments; components of light reaction, light harvesting complexes; photo-oxidation of water; mechanisms of electron and proton transport; carbon assimilation, the Calvin cycle (C3 cycle), C4 cycle, CAM pathway; characteristics of C3, C4 and CAM plants; photorespiration and its significance.

BOT-14: ECOSYSTEM ECOLOGY

Unit I

Ecosystem organization: biotic component-food chains, food web, trophic cascades; abiotic component-soil formation, soil profile development, soil horizons and soil classification.

Unit II

Ecosystem function: primary production (gross and net primary production, controlling factors and methods of measurement), energy flow pathways, ecological efficiencies; litter accumulation and decomposition (mechanisms, substrate quality and climatic factors); global bio-geochemical cycles of C, N, P and S (pathways, processes, budgets and anthropogenic impact).

Unit III

Ecosystem Management: nature and societal response to environmental problems; environmental impact assessment (EIA) methodology and role in environmental conservation- contents and conceptual framework of EIA; sustainable development- concept and indicators of sustainability
Restoration Ecology: concept, concerns, strategies and planning; biodiversity-ecosystem function relationship (BEF).

Unit IV

Applied ecology: global climate change (causes, consequences and mitigations); greenhouse gases- sources, trends and role; global warming, CO_2

fertilization, ozone depletion and ozone hole; UV radiation and their impact, response of plants to tropospheric ozone acid precipitation- components and impacts; impact of SO_2 on plants; eutrophication of aquatic ecosystems- sources and impacts; soil pollution- kinds and sources of pollutants, response of plants to heavy metals.

Bot.15: Optional Courses

Bot.15: MOLECULAR ECOLOGY-I

Unit I

Introduction to molecular ecology: definition and genesis; scope and applications of molecular ecology; milestones achieved in molecular ecology and future challenges.

Unit II

Molecular Evolution: evolutionary molecular ecology, concept of neutral evolution, molecular divergence and molecular clocks; molecular phylogenetics (concept, tools and applications, molecular basis of adaptive variations and ecologically important traits; origin of new genes and proteins.

Unit III

Molecular markers in ecology: molecular markers and their role in ecology; inheritance of molecular markers (nuclear vs. organelle, haploid chromosomes, uniparental markers); types of molecular markers - codominant markers (allozymes, RFLPs, DNA sequences, SNPs), dominant markers – RAPD, AFLP).

Unit IV

Molecular identification and characterization: taxonomic delimitation at individual, population and species level using molecular characters; molecular identification methods (protein analysis, DNA analysis), DNA barcoding; linking molecular data with other sources for delimitation of taxonomic units.

Bot-15: ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY- I

Unit I

Economic Botany: historical development, present concept; ethnobotany- concept and scope; archaeo-ethnobotany- concept, scope, and role in tracing origin and evolution of domesticated plants.

Plant quarantine: methods and significance of plant quarantine in introduction of new crops through seed/fruit import.

Plant introduction: concept and concerns

Unit II

Cereals and Millets: origin and evolution, domestication and improvement of *Hordeum*, *Fagopyrum* and *Sorghum.*

Beverages: origin, evolution, domestication and processing of tea and coffee.

Legumes as sources of food: forage and nitrogen fixation, pulses - distribution and production in India

Unit III

Reproductive modes in flowering plants: an overview, essence of sexual reproduction, costs and benefits

Role of reproductive biology in plant conservation.

Sex expression: types and control; gender expression in monoecious and dioecious plants.

Unit IV

Breeding systems in relation to crop improvement: selection and breeding methods for self-pollinated crops; concept of pure lines.

Selection and breeding methods in cross-pollinated crops: inbreeding depression and hybrid vigour- various theories.

Incompatibility and its role in plant breeding: fertilization, pollen germination, incompatibility- gametophytic and sporophytic

Bot. 15: CROP PHYSIOLOGY-I

Unit I

Water relations: water relations of plant cell (water potential and its components, diffusion, osmosis and bulk flow); movement of water through soil-plant- atmosphere continuum; stomatal transpiration, role of transpiration; water use efficiency and crop productivity.

Unit II

Phloem transport: transport of materials in phloem, direction, rates and factors affecting phloem transport, source-sink relationship and its bearing on yield.

Unit III

Mineral nutrition: availability of ions in soil, absorption, and assimilation of mineral nutrients (N, P and S) by crops; plant nutrient responses.

Unit IV

Photosynthesis: photosynthesis in crop plants at organ, plant and canopy level; Improving photosynthetic efficiency for greater yield; effect of environmental factors on photosynthesis (light, temperature, carbon dioxide); leaf factors and photosynthesis; photo-respiration and its significance.

Bot. 15 PLANT PATHOLOGY-I

Unit I

Pathogenecity and nature of disease: history of plant pathology; pathogens and pathogenesis; Koch's postulates: nature and concept of diseases in plants; classification of plant diseases, significance of plant diseases; mode of development of diseases; inoculum, types, sources and survival of inoculum, inoculum potential and factors affecting inoculum potential, penetration of pathogen through intact plant surfaces, penetration of pathogen through natural openings (stomata, hydathodes, lenticels and wounds); post penetration of pathogens and its colonization within the infected plant.

Unit II

Plant disease epidemiology: elements of plant epidemics, host factors and pathogen factors affecting epiphytotic development: disease forecasting in plant epidemics, assessment of inoculum of disease, monitoring weather factors that affect disease development, examples of plant disease forecasting system, farmers warning system; dissemination of pathogen- soil, water, plant parts, insects and man.

Unit III

Pathogens attack on host physiology: effect of pathogen on photosynthesis; effect of pathogen on host plant respiration; effect of pathogen on translocation; effect of pathogen on upward translocation of water and inorganic nutrients in host plant; effect of pathogen on downward translocation of organic nutrients through phloem; effect of pathogen on permeability of cell membrane.

Unit IV

Plant defence against pathogens: structural or morphological defence: pre-existing defence structures, defence structures formed in response to infection by pathogens; metabolic (biochemical) defence: pre-existing biochemical defence induced by attacking pathogens; metabolic defence induced by the attacking pathogen.

Bot. 15: CROP GENETICS AND MOLECULAR BREEDING-I

Unit I

Aims and objectives of plant breeding: hybridization techniques and utility, concept of germplasm and gene pool, genetic variability and genetic erosion.
Modes of pollination in crop plants, mechanism promoting self and cross pollination, genetic and cytoplasmic male sterility; self incompatibility - types, genetics and utility.

Unit II

Methods of crop improvement in self pollinated crops: Genetic composition of self-pollinated crops, progeny test, pureline theory, effect of selection in plant breeding.
Types of selection: mass selection, pureline selection, backcross method, merits and demerits, achievements, origin of genetic variation in purelines.

Unit III

Methods of crop improvement in cross pollinated crops: genetic composition of cross pollinated crops, mating systems in cross pollinated crops, heterosis and inbreeding depression - genetic basis.
Population improvement method - progeny selection (ear to row method), recurrent selection for general and specific combining ability, production of hybrid varieties concept and utility, merits and demerits of hybrid varieties.

Unit IV

Wide hybridization: barriers in the production of distant hybrids and methods of overcoming these barriers, sterility in distant hybrids, applications of distant hybridization in crop improvement.
Apomixis: types of apomixis, production of apomictic seed, utility of apomixis in crop improvement. Organizations for crop improvement- IARI, NBPGR, CIMMYT, IRRI (brief idea).

BOT-15: PLANT SYSTEMATICS AND DIVERSITY-I

Unit I

Plant systematics and biodiversity: systematics, biosystematics and experimental taxonomy; role of systematics in biodiversity science; taxonomic impediment and global taxonomic initiative; diversity and phylogeny of land plants (bryophytes, pteridophytes, gymnosperms and angiosperms).

Unit II

Practice of plant systematics: plant discovery (foray, exploration trips, expeditions); plant collection (specimen preparation and preservation); plant description (vegetative and reproductive characters); plant nomenclature (principles and procedures); biocode and phylocode (an elementary idea).

Unit III

Process and products of plant systematics: process of classification (grouping and ranking); salient features of classification systems (Bentham & Hooker, and Angiosperm Phylogeny Group); herbaria (importance and present status); botanic gardens (networking and present status).

Unit IV

Conservation biogeography: biogeography (a historical overview); bio-realms (a brief account); endemism (concept and types); measurement of biodiversity (sampling unit – shape, size and number, issue of scale); concept and applications of phylogenetic and functional diversity; types and use of biodiversity surrogates; role of remote sensing and GIS in biodiversity assessment and monitoring.

L-03 (Lab. Course) Based on Courses Bot. 11 to Bot. 14

1. Study of mitotic index from suitable plant material.
2. Techniques of preparation of permanent and semi permanent slides.
3. Carmine, Orcein and Feulgen staining of the chromosomes – preparation of stains.
4. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
5. Working out the effect of mono- and tri-somy on plant phenotype, fertility and meiotic behavior.
6. Isolation of plant DNA and its quantification by spectrophotometric method.
7. Plant DNA extraction using standard protocols.
8. Isolation of DNA and preparation of “cot” curve.

9. Induction of polyploidy using colchicine in different ways.
10. Study of PMC-meiosis in different materials.
11. Study of Mendlian genetics through use of seed mixture.
12. Estimation of reducing sugars in a sample by titrimetric method.
13. Estimation of total titrable acidity in the plant material.
14. Determination of saponification value of a given fat or oil.
15. To study the effect of time and enzyme concentration on the rate of reaction (e.g. action of diastase on starch) by spot plate method.
16. To study the effect of substrate concentration on the activity of enzyme and determination of its Km value.
17. Study of enzyme kinetics with respect to the effect of pH.
18. Extraction and separation of chloroplast pigments in the plant material by partitioning into different solvent systems.
19. Separation of chloroplast pigments by thin layer chromatography.
20. Determination of rate of photosynthesis in an aquatic plant by Winkler's method.
21. Determination of succinate dehydrogenase activity.
22. To study principles of colorimetry and spectrophotometry.
23. Extraction of chloroplast pigments from leaves and preparation of absorption spectrum of photosynthetic pigments and anthocyanins.
24. Determination of activity of polyphenol oxidase and peroxidase.
25. To determine the soil texture, aggregate stability, porosity and bulk density of various soil samples collected from different sites.
26. To determine the moisture content and water holding capacity of soil samples collected from different locations
27. To find out the percentage organic carbon and organic matter content in soils of cropland, grassland and forest.
28. To determine the carbon stock in different plant systems.
29. To estimate the dissolved oxygen content in different water samples.
30. To use the BOD test for assessment of the level of organic pollution in water samples.
31. To study the environmental impact of a given developmental activity using checklist as an EIA method.

L-04 (Lab. Course) Based on Optional courses

MOLECULAR ECOLOGY-I

1. Sterilization of glassware, growth medium and other materials
2. Preparation of various culture media
3. Techniques of inoculation and characterization of colony morphologies
4. Measurement of microbial growth rate

5. Extraction of genomic DNA from soils
6. DNA extraction from plants
7. Amplification of DNA by PCR
8. Extraction of proteins and estimation of protein content

ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY-I

1. Study of comparative characteristics of the grains of cereals, millets and pulses.
2. Study of food reserves in different food crops using microchemical tests.
3. Study of methods of cultivation, processing and uses of various rosaceous fruits of Kashmir.
4. Studies on MAP's of Kashmir with respect to status, distribution pattern, adaptability and threats, if any
5. Study of pmc meiosis of different plant species.
6. Pollen viability tests: germination tests, chemical tests.
7. Stigma receptivity and self-incompatibility
8. Survey of various tribal areas of Kashmir valley to compile an inventory of ethno-botanically important species of the region (name, local name, part used, uses, method of use, degree of popularity and precautions, if any)
9. Survey of archaeological sites (Burzhama) to study the significance of such sites in tracing the origins of agriculture and history of domestication of various plants This will include studies on archaeological plant remains from this site
10. Study of various aspects of seed biology useful in *ex situ* conservation of rare and threatened economically important plants

CROP PHYSIOLOGY-I

1. Preparation of calibration curves for the estimation of following tissue constituents in the plant material:

a.) reducing sugars	b.) non-reducing sugars
c.) total Sugars	d.) total starch content
e.) soluble proteins	f.) α-amino acids
g.) total phenolics	h.) inorganic phosphorus

2. Separation and estimation of photosynthetic pigments (chlorophyll-a, chlorophyll-b, total chlorophyll, carotenoids) and anthocyanins.
3. To study the effect of pH, enzyme concentration, substrate concentration and time course on the activity of the enzymes.

PLANT PATHOLOGY-I

1. Morphological studies and identification of the following fungi through temporary and permanent mounts- *Peronospora, Mucor, Rhizopus, Penicillium, Aspergilus* and *Alternaria, Albugo, Polyporus, Phoma*
2. Symptomology and studies of some local diseased plant materials through temporary and permanent mounts : powdery mildew of cucurbits and composites, smuts, leaf spot diseases
3. Sterilization of media and glass ware, preparation of culture of some local fungal flora
4. Preparation of culture media ,peptone dextrose agar(PDA), soil extract agar, Richard's solution, Czepek's solution, Coon's medium
5. Inoculation of media by dilution plate method
6. Isolation of plant pathogens from infected tissue by tissue segment method
7. Preparation of some fungal stains
8. Demonstration of cell wall degrading enzyme production by *Rhizopus and Mucor* on potato tuber discs
9. Acquaintance with fungicides, bio-control agents and spray equipments
10. Isolation of nematodes by Cobb's sieving and decanting techniques
11. Isolation and purification of viruses by density gradient centrifugation

CROP GENETICS AND MOLECULAR BREEDING-I

1. Field demonstration of self and cross pollinated plants with suitable examples.
2. Study of hybridization techniques in the field.
3. Study of floral modifications that favor inbreeding and out breeding.
4. Mitotic and meiotic chromosome analysis using suitable plant material.
5. Determination of mitotic index.
6. Analysis of pollen to ovule ratio as an index of the nature of breeding system in some crops.
7. Study of different chromosomal aberrations and their effect on fertility.
8. Study of stigma structure of the species showing gametophytic and sporophytic incompatibility.

PLANT SYSTEMATICS AND DIVERSITY-I

1. Character variation studies in different populations of the same species.
2. Character variation studies in different species of the same genus.
3. Character variation studies in different genera of the same family.
4. Study of morphological micro-variants by histogram method in some suitable plants.

5. Study of morphological micro-variants by scatter diagram in some suitable plants.
6. Study of morphological micro-variants by polygraph method in some suitable plants.
7. Study of the floral morphology of suitable plant species showing different sex types.
8. Study of cleistogamy and heterostyly in some suitable plants

Semester IV

BOT-16: PLANT PHYSIOLOGY

Unit I

Membrane transport and translocation of water and solutes: plant water relations (water potential and its components), mechanisms of water transport through xylem, root–microbe interactions in facilitating nutrient uptake, phloem transport, phloem loading and unloading, membrane transport proteins and processes.

Unit II

Signal transduction: general concept, diversity in protein kinases and phosphatases, G-proteins , phospholipid signaling, calcium-calmodulin cascade, annexins, cyclicAMP (cAMP), specific signalling mechanisms e.g. two component sensor-regulator system in bacteria and plants, sugar-sensing and signalling in plants (brief concept).

Unit III

Sensory photobiology: phytochromes and cryptochromes- discovery, photochemical and biochemical properties; structure, cellular localization; phytochrome- and cryptochrome-mediated responses; photoreceptor signal transduction.

Unit IV

Plant growth regulators and elicitors: physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroides, polyamines, jasmonic acid and salicylic acid.

The control of flowering: floral induction and development, endogenous clock and its regulation; photoperiodism and vernalization.

BOT-17: GENETIC ENGINEERING OF PLANTS AND MICROBES

Unit I

Recombinant DNA technology: Gene cloning principles, restriction enzymes, other enzymes involved in recombinant DNA technology, cloning vehicles and their properties (plasmids, phages, phagemids and cosmids), artificial chromosomes (YAC).

Construction of recombinant DNA, gel electrophoresis, southern blotting, genomic and cDNA libraries, bacterial transformation and selection of recombinants.

Unit II

Isolation of gene of interest, genomic and cDNA libraries, molecular probes and their utility, DNA sequencing methods.
Polymerase chain reaction (PCR) – principle, technique and applications, Molecular markers - concept of RAPD, AFLP, RFLP, SSR and SNP; use of molecular markers in DNA fingerprinting.

Unit III

Genetic engineering of plants: Agrobacterium the natural genetic engineer, Ti and Ri plasmids, disarming of Ti plasmid, binary vectors, mechanism of gene transfer, detection of transgenics (reporter genes), applications of transgenic plants.
Direct methods of gene transfer (electroporation and biolistics), T-DNA and transposon mediated gene tagging, chloroplast transformation and its utility, biosafety - possible ecological risks and ethical concerns of GM crops.

Unit IV

Genomics: concept of genomics, sequencing of genomes, genome sequencing projects -their importance and achievements, the Human Genome Project; functional genomics- concept and importance, microarray technology and its applications.
Proteomics - concept and importance; bioinformatics – introduction, databases and analysis tools, brief account of antisense RNA technology, gene silencing and RNA interference (RNAi).

BOT 18: PLANT CELL TISSUE AND ORGAN CULTURE

UNIT I

Introduction : historical perspectives and scope of plant tissue culture.
Principles of plant tissue culture : media composition and preparation , aseptic manipulations.
Cellular totipotency : concept, cytodifferentiation and its mechanism.

UNIT II

Cell culture and cell cloning : isolation of single cells from plant organs and cultured tissues, culture of single cells; viability assessment of cultured cells.
Organogenesis : process and controlling factors.
Somatic embryogenesis: induction, development , maturation. Applications of somatic embryos.

UNIT III

Haploids : androgenic and gynogenic, ontogeny of androgenic haploids, applications of haploids in plant breeding

Somatic hybridization :isolation, culture and fusion of protoplasts. Selection, regeneration and utility of hybrids and cybrids.

Clonal propagation : micropropagation, factors affecting in vitro stages of micropropagation, applications and limitations of clonal propagation.

UNIT IV

Somaclonal and gametoclonal variations: origin, induction and selection of variants. Achievements and prospects.

Industrial applications: production of secondary metabolites and their applications, suspension cultures, hairy root cultures and bioreactors.

Germ plasm conservation: cryopreservation of plant cells and organs, short term and long term storage, synthetic seed technology and utility of synthetic seeds.

BOT 19: BIOSTATISTICS AND BIOTECHNIQUES

Unit I

Data types and collection: data types- data on ratio, interval, ordinal and nominal scales; continuous and discrete data; methods of primary and secondary data collection and their limitations, frequency and cumulative frequency of distributions.

Processing and analysis of data: measures of central tendency- arithmetic mean, mode, median; measures of dispersion- mean deviation, variance, standard deviation, coefficient of variation.

Unit II

Design and analysis of experiments: principles of experimentation; experimental designs- layout, analysis of variance and comparison of treatments in completely randomized design, randomized complete block design, and factorial experimental designs; transformation of data.

Sampling techniques: principles and various steps in sample survey; procedures and practices involved in simple random sampling, systematic, stratified and multistage sampling.

Unit III

Testing of hypothesis: basic concepts, procedure for hypothesis testing; test difference between means (-independent and paired samples); test of proportions and test of goodness of fit.
Simple correlation: basic idea, calculation of an estimated correlation coefficient, significance tests for correlation coefficients; simple linear regression- calculation of regression coefficient, standard errors and significance test.

Unit-IV

Chromatography: – principles and applications of paper, thin layer, column and chiral chromatography; HPLC, ion exchange, affinity, gas liquid chromatographic techniques; gel electrophoresis and ultra centrifugation .
Bio Physical Methods: Concepts of spectroscopy, Laws of photometry, Beer-Lambert's law, use of various spectroscopic techniques like UV - visible, IR, NMR and mass spectroscopy in biology.
Radio labelling Techniques: Properties of different radioisotopes and their applications in biology, Safety guidelines
Microscopy: Principles and applications of Light, Electron and Fluorescence microscopy.

BOT-20: Optional Courses

BOT-20: MOLECULAR ECOLOGY-II

Unit I

Molecular microbial ecology: microbial diversity assessment (culture-dependent and culture-independent approaches), ribosomal genes and genetic profiling of microbial communities; genome analysis and microbial ecology, sequence complexity, microarrays, and other genomic approaches in molecular ecology.

Unit II

Molecular ecology and environmental monitoring: molecular ecology and genetically modified organisms (GMOs), vertical and horizontal gene transfer, use of GMOs for environmental concerns, soil ecological effects of GMOs; microorganisms and waste water treatment; commercial blends of microbes and enzymes in wastewater treatment; biosensors in relation to pollution monitoring; bioremediation.

Unit III

Conservation genetics: genetic diversity in natural populations; loss of genetic diversity as a conservation concern, conservation units; genetic diversity and population size, metapopulations; inbreeding and outbreeding depression, genetic load, genetic restoration; molecular markers in conservation genetics; role of molecular genetics in plant conservation.

Unit IV

Phylogeography: concept and scope; use of molecular markers in phylogeography- microsatellite markers and mtDNA; genetic variation in space and time- vicariance, dispersal, lineage divergence in real time, dispersal of invasive plant species; applications of phylogeography- determining species natural range, finding the source populations of introduced species.

Bot-20: ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY- II

Unit I

Fibres: classification of fibres; origin, evolution, domestication, extraction and utilization of cotton.
Sugars and Starch: origin, evolution, domestication, extraction and utilization of cane sugar and beet sugar; general account of starch yielding plants.
Rubber: origin, distribution, production, extraction, processing and utilization of rubber.

Unit II

Medicinal systems: historical development and potential of Chinese, Ayurvedic and Unani system of medicine
Industrial utilization of important medicinal plants: medicinal and aromatic plants of Kashmir Himalaya with special reference to the status, use, misuse, economic potential of *Aconitum heterophyllum*, *Atropa acuminata*, *Arnebia benthamii*, *Artemisia maritima* and *Rheum emodi*.
Utility of plants in future: innovations for meeting world food requirements; food adulteration

Unit III

Pollination types: delayed pollination, hybrid seed production, male sterility.
Polyploidy and its role in plant breeding: consequences of polyploidy, role of artificial polyploids in plant breeding; distant hybridization (role of hybrid sterility in nature), consequences of remote hybridization.
Apomixes: concept, types and benefits; genetic control and evolutionary significance

Unit IV

Genetic basis of self incompatibility: mechanism for breakdown of self incompatibility; parasexuality hybridization, methods and importance.
Male sterility: types, naturally occurring and induced; male sterility genes and their action, structure and biochemical characters.
Seed development: general account and patterns; ovule abortion-causes and consequences.

Bot.20: CROP PHYSIOLOGY-II

Unit I

Growth analysis and yield of crop plants: principles and practices of plant growth analysis, concept and computation of basic growth analytical parameters - net assimilation rate (NAR), leaf area ratio (LAR), leaf weight ratio (LWR), relative growth rate (RGR), leaf area index (LAI), crop growth rate (CGR), relation between growth and yield (Harvest index).

Unit II

Stress physiology: Disturbance and syndrome, Responses of plants to abiotic stresses (draught, freezing and salinity), acclimation and stress tolerance.

Unit III

Senescence and post harvest physiology of cut flowers: flower as model system for studying senescence, ethylene as modulator of flower senescence, post harvest quality requirements in cut flowers; storage, packaging and transport of cut flowers; techniques for improvement of longevity in cut flowers.

Unit IV

Chemical control of plant growth- role of PGR's (auxins, gibberellins, cytokinins, ethylene and growth retardants) in agriculture and horticulture.

Bot. 20 PLANT PATHOLOGY-II

Unit I

Symptomology of fungal, bacterial and viral infections of plants.
Induction of diseases in plants: role of enzymes and microbial toxins in pathogenesis; aflatoxins, occurrence and historic perspective, major types, properties and toxicity

Unit II

Fungal diseases: etiology and control of club root of crucifers, downy mildews of onion, loose smut of wheat, early blight of potato, rhizopus soft rot of fruits and vegetables, *Fusarium* wilt of tomato

Bacterial diseases: general characteristics; etiology and control of bacterial leaf streak of rice, fire blight of apples and pears, citrus canker, bacterial soft roots of vegetables.

Unit III

Viral and viriod disease: general characteristics; cucumber mosaic virus, cauliflower mosaic virus, brinjal mosaic virus, prunus necrotic spot virus, Potato spindle tuber and citrus exocortis.

Nematode diseases: general characteristics; symptoms, biology and control of nematode pests causing diseases: root knot diseases of plants, ufra disease of rice, reniform nematode disease of vegetables.

Mycoplasma in plant diseases: general characteristics of ML's; sandle spike disease, eucalyptus little leaf and citrus greening.

Unit IV

Pest management: regulatory methods: quarantine and inspection; physical methods: soil sterilization, hot water treatment, hot air treatment, radiation treatment, refrigeration; cultural methods: crop rotation, sanitation, creating conditions on unfavourable to the pathogens, organic amendments, breeding of resistant varieties: chemical methods; types of chemicals , methods of application of chemicals; inorganic and organic chemicals and fungicides, mode of action of fungicides, antibiotics: biological methods: use of fungi, bacteria and antagonistic plants as biocontrol agents, trap plants; integrated pest management in plant disease control

Bot-20: CROP GENETICS AND MOLECULAR BREEDING-II

Unit I

Quantitative traits: continuous variation, polygenic inheritance and multifactor hypothesis, genetics of metric traits, role of environment in polygenic inheritance.

Mutation breeding: concept of physical and chemical mutagens – role of induced mutations in crop improvement, somaclonal variations in crop improvement.

Unit II

Molecular breeding: Methods of production of transgenic plants (agrobacterium mediated gene transfer, electroporation, biolistics), applications of transgenic plants in crop improvement (nutritional quality, male sterility, edible vaccines, golden rice).
Transplastomic plants – concept, applications and limitations of chloroplast transformation, problems associated with gene transfer in plants.

Unit III

Stress resistance: Drought and temperature resistance mechanisms, genetic engineering approaches in developing drought and cold tolerance crop plants.
Disease resistance mechanisms, vertical and horizontal resistance, genetics of disease and insect resistance, gene for gene relationship (molecular basis), genetic engineering approaches in developing herbicide resistance, insect resistance, resistance against plant viral and fungal diseases.

Unit IV

Molecular markers: types and utility of molecular markers in genetic diversity analysis in crop plants, molecular markers for introgression of useful traits, marker assisted selection in crop plants.
Biofertilizers - genetic engineering of symbiotic nitrogen fixation – organization and role of Nif genes, Hup genes and Nod genes. QTL mapping and its applications in crop plants.

BOT-20: PLANT SYSTEMATICS AND DIVERSITY–II

Unit I

Systematics as a synthetic field: ecotypes (origin, types and taxonomic treatment); population biology (sources and kinds of variation); plant breeding systems (types and their taxonomic implications); pollination biology (modes of pollination, coevolution between plants and pollinators).

Unit II

Hybridization, speciation and species concepts: hybridization and its role in plant evolution, mechanisms of hybrid stabilization; isolating mechanisms (pre-mating and post-mating); process of speciation (allopatric, parapatric and sympatric); major species concepts (a brief account), merits and demerits of biological species concept.

Unit III

Molecular systematics and cybertaxonomy: sources of DNA-based characters (mtDNA, cpDNA and nrDNA); use of molecular markers in plant systematics citing relevant examples (RFLP, RAPD, AFLP, SSR); DNA Barcoding (concept, applications and limitations); biodiversity informatics (concept and applications), e-floras and e-herbaria.

Unit IV

National and regional plant diversity: plant diversity in India (present status and conservation concerns); biogeographical classification of India; forest types of India; Indian biodiversity hotspots (overview, human impacts and conservation action); plant diversity in Kashmir Himalaya (present status, current threats and conservation measures).

L-05 (Lab. Course) Based on Courses Bot. 16 to Bot. 19

1. Determination of water potential of potato tuber tissues by gravimetric method.
2. Determination of water potential of potato tuber tissues by Chardakov's falling drop method.
3. Determination of osmotic potential of onion epidermal peels by plasmolytic method.
4. Determination of Q_{10} of water absorption of a given plant material.
5. Determination of stomatal frequency and stomatal index of leaf material.
6. Determination of effect of organic solvents on membrane permeability of plant tissues.
7. Study of effect of temperature on membrane permeability of plant tissues.
8. To study the physiological effects of auxins, gibberellins and cytokinins.
9. Estimation of membrane permeability of a given plant tissue by measuring conductivity of leacheates.
10. Isolation of plant genomic DNA and its quantification by UV-spectrophotometric method.
11. Restriction digestion of DNA and its analysis by Agarose gel electrophoresis
12. Demonstration of DNA sequencing by Sanger's dideoxy method.
13. Demonstration of RAPD and AFLP analysis.
14. Isolation of gene of interest using cDNA library.
15. Demonstration of PCR, centrifuge, deep freezer, and gel electrophoresis apparatus.
16. Washing and sterilization of glassware.
17. Sterilization of growth media.
18. Sterilization of various types of plant materials.
19. Aseptic inoculations under laminar airflow hood.
20. Composition and preparation of plant tissue culture medium.

21. Techniques for establishment of callus cultures and study of different types of calli viz. Compact, friable and nodular types.
22. Establishment of zygotic embryo cultures.
23. In vitro differentiation of roots and shoots in suitable explants.
24. Demonstration of rhizogenesis in *Glycine max.*
25. Collection of raw data on different parameters and classification of ungrouped data into grouped data (discrete and continuous series) i.e. frequency distribution
26. Frequency distribution table and Construction of Simple bar chart, Histogram and Scatter plot.
27. To find the various measures of central tendency (mean, mode and median) of the given data.
28. To find the various measures of dispersion (mean deviation, standard deviation, variance and coefficient of variation) of the given data.
29. Drawing of a sample from a given population by various sampling techniques (simple random, systematic and stratified sampling)
30. To perform One-way ANOVA and Two-way ANOVA of the given data sets.
31. Correlation, linear regression.
32. Gel electrophoresis techniques and analysis.
33. Paper and thin layer (TLC) chromatography.

L-06 (Lab. Course) Based on Optional courses

MOLECULAR ECOLOGY-II

1. Quantification of DNA content
2. Use of molecular markers such as RFLP, RAPD
3. Analysis of the RFLP pattern for identification of Operational Taxonomic Units
4. Inference of evolutionary histories from molecular data
5. Estimation of degree of relatedness from molecular data or allele frequencies
6. Calculation of allele frequencies from phenotypic data
7. Estimation of Hardy-Wienberg equilibrium
8. Determining the effective population size
9. Assessment of genetic distance

ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY - II

1. Study of various oil yielding plants (morphology of the part, study of distribution pattern of oil bodies in the tissues and microchemical tests of oil).

2. Study of the nature of breeding systems in some flowering plants through bagging experiments.
3. Study of karyotype of any given species using dividing root tips and estimation of the degree of the asymmetry in the karyotype.
4. Study of various fumigatories and mastigatories viz tobacco, betelvine, and arecanut.
5. Study of different types of surface and bast fibres (morphological and anatomical study).
6. Study of botany, uses and abuses of some poisonous plants: *Papaver somniferum, Cannabis sativa* and *Datura stramonium.*
7. Study of botany, part used and uses of some aromatic plants: *Lavendula officinale, Mentha arvensis*, and *Artemisia maritime, A. absinthium and A. annua.*
8. Studies on somatic chromosome complements.
9. Study of various aspects of seed biology useful in *ex situ* conservation of rare and threatened plants.
10. Survey of local forest regions to prepare a herbarium of 50-100 important medicinal, aromatic, poisonous, food, fodder and timber plants
11. Project work

CROP PHYSIOLOGY-II

1. Analysis of growth and yield:
   - i.) Dry matter partitioning into roots, leaves and branches.
   - ii.) Computation, assessment and comparison of important growth parameters:
     - a.) Net assimilation rate (NAR)
     - b.) Leaf area ratio (LAR)
     - c.) Leaf weight ratio (LWR)
     - d.) Relative growth rate (RGR)
     - e.) Harvest index (HI)
     - f.) Biomass duration (BMD)
     - g.) Leaf area duration (LAD)
2. Separation of proteins by polyacrylamide gel electrophoresis (PAGE)
3. Study of the physiological effects of the following growth regulators:
   i.) auxins ii.) gibberellins iii.) cytokinins

PLANT PATHOLOGY-II

1. Morphological studies and identification of the following fungi through temporary and permanent mounts: *Cercospora, Fusarium, Morchella, Agaricus, Venturia, Taphrina, Saccharomyces and collelotrichum*
2. Symptomology and studies of some local diseases plant material through temporary and permanent mounts; powdery mildews of grasses, powdery mildews of apple and rose; downy mildew of onion, damping off of chillies, Alternaria disease of apples, Rhizopus rot of vegetables, Rust of wheat and willows

3. Sterilization of media and glassware; preparation of culture of some local fungal flora
4. Preparation of culture media, PDA, peptone dextrose agar, soil extract, Richard,s solution, solution, coons medium
5. Purification of fungal cultures- dilution plates, tube dilution
6. Maintenance of culture- agar slants, flasks, petridishes, under soil
7. Inoculation of plants in soil
8. Isolation of plant pathogen from soil, air and water
9. Isolation of nematodes by Cobb's sieving and decanting techniques
10. Isolation and purification of viruses by density gradient centrifugation

CROP GENETICS AND MOLECULAR BREEDING-II

1. DNA extraction methods and protocols.
2. Induction of polyploidy by colchicines treatment.
3. Karyotype analysis in any two plant species.
4. Study of pollen ovule ratios using suitable plant material..
5. Elementary statistical analysis of the phenotype variability of any available species using a random sample of 10 plants.
6. Estimation of heritability.
7. Chi square test using suitable seed material.
8. Effect of physical/chemical mutagens on seed germination and seedling growth.
9. RFLP, RAPD analysis through diagrammatic sketches/photographs.

PLANT SYSTEMATICS AND DIVERSITY-II

1. Herbarium (each student has to submit a herbarium comprising of plant specimens of their area of residence)
2. Study of pollination mechanisms in some suitable plants
3. Study of pollen types by acetolysis method.
4. Study of various placentation types.
5. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.
6. Demonstration on various internet resources on plant systematics and diversity.
7. To describe the plant species by using a comprehensive morphological character list.
8. To draw the illustration of various plant parts, such as whole plant, leaves, whole flower, flower parts etc.
9. To determine the synonymy of plant taxa by using taxonomic literature.

Suggested Readings

BOT-01: VIRUSES, BACTERIA, FUNGI AND PLANT PATHOLOGY

1. Alexopolus, C.J., C.W. Mims and M. Blackwell. 1992. Introductory Mycology, 4th edition. John Wiley and Sons Inc. Asia Pvt. Ltd
2. Webster, J. 1986. Introduction to Fungi, 3rd edition, Cambridge University Press
3. Gow, N. A. R. and Gadd, G. M. 1996. The growing Fungus, 3rd Edition, Chapman and Hall London and Madras.
4. Mehrotra, R.S. and Aneja, R.S. 1996. An introduction to Mycology, 3rd Edition. New Age Intermediate Press, N. Delhi.
5. Singh, R. S. 1996. Plant Diseases. 6th edition, Oxford and IBH Publishers Co. Pvt. Ltd
6. Singh, R. S. 1996. Introduction to Principles of Plant Pathology, 6th edition. Oxford and IBH Publishers Co. Pvt. Ltd
7. Agrios, G. N. 2000. Plant Pathology. Academic Press
8. Cooke, R. 1977. The Biology of Symbiotic fungi. Wiley-Blackwell

BOT-02: ALGAE, BRYOPHYTA AND PTERIDOPHYTA

1. Fritsch, F.E. 1979. The structure and reproduction of algae. Vols. I and II. Cambridge University Press.
2. Prescott, G.W. 1984. The Algae: A Review. Otto Koeltz Science Publishers, Germany.
3. Bold and Wynne. 1985. Introduction to the Algae. Prentice Hall, USA.
4. Kumar, H.D. 199. Introductory Phycology. East-west Press New Delhi.
5. Watson, Eric Vernon. 1971. The Structure and life of Bryophytes. Hutchinson and co Publishers Ltd.
6. Shaw, A. J. and Goffenel, B. 2000 Bryophyte Biology. Cambridge University, Press.
7. Rashid, A. 2003. Text Book of Bryophyta. Vikas Publishers N. Delhi.
8. Rashid, A. An Introduction to Pteridophyta. Vikas Publishers N. Delhi
9. Parihar N.S. The biology and Morphology of Pteridophytes. Central Book Depot. Allahabad.
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BOT-03: BIOLOGY AND DIVERSITY OF GYMNOSPERMS

1. Chamberlain, C. J. 1966. Gymnosperms: structure and evolution. Chicago, Ill., The University of Chicago Press.
2. Sporne, K. R. 1974. The morphology of gymnosperms: the structure and evolution of primitive seed-plants. Hutchinson Co Ltd.

3. Bierhorst, D. W. 1971. Morphology of vascular plants.MacMillan Pub Co, New York.
4. Stewart, W. N. and Rothwell, G. W. 1993.Paleobotany and the evolution of plants.Cambridge University Press.
5. Foster, A. S. and Gifford, E. M. 1974. Comparative morphology of vascular plants.W. H. Freeman and Co.
6. Foster, A. S. and Gifford, E. M. 1989. Morphology and evolution of vascular plants.W.H. Freeman and Co.
7. Taylor, T. N; Taylor, E. L. and Krings, M. 2009.Paleobotany: The Biology and Evolution of Fossil Plants. Academic Press.
8. Beck, C. B. 1988.Origin and evolution of gymnosperms.Columbia University Press.
9. Singh, V. P. 2006. Gymnosperm (naked Seeds Plant).Sarup and Sons, New Delhi.

BOT-04: PLANT TAXONOMY, BOT-15: PLANT SYSTEMATICS AND DIVERSITY– I, and Bot. 20: PLANT SYSTEMATICS AND DIVERSITY– II

1. Singh, G. 2004. Plant Systematics: An Integrated Approach. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Stuessy, TF. 2009. Plant Taxonomy: The Systematic Evaluation of Comparative Data. Columbia University Press, New York.
3. Stace, C.A. 1980. Plant Taxonomy and Biosystematics. Arnold, London.
4. Simpson, M.G. 2006. Plant Systematics. Elsevier.
5. Sivarajan, V.V. 1992. Introduction to the Principals of Plant Taxonomy. Cambridge University Press.
6. Judd, W.S., Campbell, C.S., Kellog, E.A. and Stevens, P.F. 2002. Plant Systematics: A phylogenetic Approach. Sinnauer, Sunderland, USA.
7. Grant, V. 1971. Plant Speciation. Columbia University Press.
8. Davis, P.H. and Heywood, VH. 1963. Principles of Angiosperm Taxonomy. Van Nostrand, Princeton.
9. Hickey, N. and King, C. 2000. The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press.
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BOT-05: PLANT RESOURCE UTILIZATION

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4. Vavilov, N. I. 1992. Origin and Geography of Cultivated Plants. Translated by Doris Love. 1992. Cambridge University Press
5. Frankel, O.H. and Hawkes, J. G. 2006. Crop Genetic Resources for Today and Tomorrow by Cambridge University Press
6. Simpson, B.B. and Ogorzally, M.C. 2003. Economic Botany by. McGraw Hill International Publishers.
7. Chalam G.V. and Venkateshwarlu, J. 2007. Agricultural Botany in India. Venkatesh Publishers.
8. Anonymous. 2009. Hand Book of Agriculture, Revised Edition 2009.,ICAR New Delhi.
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BOT-06: BIODIVERSITY AND CONSERVATION BIOLOGY

1. Dobson, A.P. 1999. Conservation and Biodiversity. Scientific American Library.
2. Gaston, K.G. and Spicer, J.I. 2004. Biodiversity: An Introduction. John Wiley & Sons.
3. Magurran, A.E. 2004. Measuring Biological Diversity. John Wiley & Sons.
4. Hunter, M.L. and Gibbs, J. 2008. Fundamentals of Conservation Biology. Blackwell Publishing, USA
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BOT-07: DEVELOPMENT IN ANGIOSPERMS

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3. Srivastva, L. M. 2002. Plant Growth and Development: Hormones and Environment. Academic Press, London.
4. Beck, C. B. 2010: An Introduction to Plant Structure and Development: Plant Anatomy. Cambridge Univ. press.
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6. William , C. Dickison 2000 Integrative Plant Anatomy Elesever , USA
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8. Crang, R., and Vassilyev , Plant Anatomy 2003 McGraw-Hill companies

BOT-08: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

1. Harder, L.D. and Barrett, C.H.S. 2006. Ecology and Evolution of Flowers**.** Oxford University Press Inc., New York.
2. Raghavan, V. 2000. Developmental Biology of Flowering Plants. Springer-Verlag Berlin Heidelberg, New York.
3. Raghavan, V. 2006. Double fertilization: embryo and endosperm development in flowering plants. Springer- Verlag Berlin Heidelberg, New York.
4. Lersten, N. R. 2004. Flowering Plant Embryology.Blackwell Publishing Ltd, Oxford, UK.
5. Bhojwani, S. S. and Bhatnagar, S. P. 1985. The embryology of angiosperms. Vani Publications, New Delhi.
6. Glover, B. J. 2007. Understanding Flowers and Flowering. Oxford University Press Inc., New York.
7. Sharma, H. P. 2009. Plant embryology: classical and experimental. Alpha Science International.
8. Batygina, T. B. 2009. Embryology of Flowering Plants: Terminology and Concepts. Science Publishers.
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BOT-09: CELL AND MOLECULAR BIOLOGY, BOT-11: CYTOGENETICS AND GENETICS and BOT-12: MOLECULAR GENETICS, BOT-17: GENETIC ENGINEERING OF PLANTS AND MICROBES
Bot. 15: CROP GENETICS AND MOLECULAR BREEDING-I and Bot. 20: CROP GENETICS AND MOLECULAR BREEDING-II

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22. Sharma, J. R. Principles and practice of plant breeding. Tata McGrow Hill Publ. Co. Ltd., New Delhi.
23. Singh B.D 2004. Genetics. Kalyani Publication, Ludhiana.
24. Singh R. K. and Singh B. D. 1997. Biometrical Methods in Quantitative genetic Analysis.
25. Singh, B. D. 2000. Plant breeding- Principles and methods. Kalyani Publishers, Ludhiana.
26. Sinha U. and Sinha S. 1998. Cytogenetics, Plant Breeding and Evolution. Vikas Publishing house Pvt. Ltd. New Delhi.
27. Strickberger 2005. Genetics. Prentice Hall of India Pvt. Ltd., New Delhi.
28. Swaminathan M. S., Gupta P. K. and Sinha U. 1974. Cytogenetics of Crop Plants. MacMillan India Ltd. New Delhi.

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30. Sybenga, J. 1975. Meiotic configurations. Springer Verlag, Berlin, Germany.

BOT-10: POPULATION AND COMMUNITY ECOLOGY and BOT-14: ECOSYSTEM ECOLOGY

1. Odum, E. and Barrett, G. W. 2004. Fundamentals of Ecology (4th Ed.).. Brooks Cole
2. Krebs, C.J. 2000. Ecology: The Experimental Analysis of Distribution and Abundance. Benjamin-Cummings
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5. Chapin III, Stuart, F., Mooney, Harold A., Chapin, Melissa C. and Pamela Matson. 2002. Principles of Terrestrial Ecosystem Ecology. Springer Verlag.
6. Lambers, H. Chapin III, F.S. and Pons, T.L. 2008. Plant Physiological Ecology. Springer Verlag.
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9. Harper, J.L. and Townsend, C. R. 1996. Ecology: Individuals, populations, and communities, Wiley-Blackwell.
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BOT-13: PLANT BIOCHEMISTRY and BOT-16: PLANT PHYSIOLOGY

1. Buchanan, B. B., Gruissem, W. and Jones, R. 2002. Biochemistry and Molecular Biology of Plants (1st Edition.)**.** John Wiley and Sons, Inc. USA.

2. Davies, P J. 2004. Plant Hormones: Biosynthesis, Signal Transduction, Action (3rd Edition). Kluwer Academic Publisher, Dordrecht, The Netherlands.
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Bot.15: MOLECULAR ECOLOGY-I and Bot.20: MOLECULAR ECOLOGY-II

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Bot-15: ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY- I and Bot-20: ECONOMIC BOTANY AND REPRODUCTIVE BIOLOGY- II

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Bot. 15: CROP PHYSIOLOGY-I and Bot. 20: CROP PHYSIOLOGY-II

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