P. G. DEPARTMENT OF BOTANY, UNIVERSITY OF KASHMIR, SRINAGAR

CHOICE BASED CREDIT BASED COURSE STRUCTURE TO BE IMPLEMENTED FROM ACADEMIC SESSION 2014-15

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 2014 onwards.

Course Structure: There will be 12 core courses (theory and lab. Combined together) in all with each semester covering 3 core courses referred as **Bot- CR**. Each core course will be worth 4credits with theory covering 3 credits and practical component 1 credit. In 1st, 2nd and 4th Semester there will be 4 elective allied while in 3rd semester there will three elective courses (one out of which will be worth 8credits- project work) referred as **Bot- EA** which will be open to students from the Department/faculty. Further, in addition to **CR** and **EA** courses there will be one elective open course referred to as **Bot-EO** which will be open to students from other subjects. Each course will be worth **4credits** and so that total course of M. Sc. Botany is comprised of **96credits**. Each course will be of 100 marks. **75 marks (3credits)** for theory component and **25 marks** in each course are for practical component. Theory component will comprise of **internal assessment of 15marks** and **external examination of 60marks**. Internal assessment of theory papers will be based on quiz tests, assignments, seminars, tutorials etc. The practical component will be evaluated 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 end of each semester examination for evaluation by the examiner/teacher(s) concerned.

Project work: Project work worth 8credits is compulsory for the students and will be assigned in 3rd semester based on choice of the student and space availability in relation to his/her choice. The project has to be submitted prior to the conduct of 4th semester examination so that it can be evaluated and viva voce be conducted prior to declaration of the results.

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,

properly preserve, and prepare atleast 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 end of the semester wherein Taxonomy is a core course.

GENERAL INSTRUCTIONS FOR THE CANDIDATES

1. The two year (4semester) programme is of 96credits i.e 24credits/semester (24x4=96)
2. A candidate has compulsorily to opt for 12credits from the core component in each semester
3. A candidate has a choice to opt any 12credits (3papers) out of minimum of 16credits (4papers) offered as Electives (Allied), except for a particular semester where a candidate is required to gain a minimum of 4credits (1paper) from Elective (Open) offered by any other Department/Faculty
4. A candidate has compulsorily to obtain a minimum of 4credits (1paper) from Elective (Open) from outside the parent Department/Faculty.
5. A candidate can earn more than the minimum required credits (i.e more than 96credits for four Semester programme) which shall be counted towards the final result of the candidate.

In the Table below the terms refer to:

L – Lecture; **T – Tutorial;**
P – Practical Work; **CR – Core Course;**
EA- Elective Allied and **EO- Elective Open**

Credit combination could be 12+12=0=24 or 12+8+4=24

i.e. 12 Core Course Credits + 12 Elective Allied course credits

or

12 Core course credits + 8 Elective Allied Course Credits + 4 Allied Open Course Credits

SEMESTER 1ST							MARKS Max. (Min)		
Course Code	Course Name	Category	Hours				Theory		Pract.
			L	T	P	Credits	Ex.	Int.	Int.
Bot-14101 CR	Plant Taxonomy	**Core**	3	0	2	**3+1**	**60(24)**	**15(6)**	**25(10)**
Bot-14102 CR	Microbiology, Fungi and Plant Pathology	**Core**	3	0	2	**3+1**	**60(24)**	**15(6)**	**25(10)**
Bot-14103 CR	Algae and Bryophyta	**Core**	3	0	2	**3+1**	**60(24)**	**15(6)**	**25(10)**
Bot-14104 EA	Herbal Medicine-Status and Strategies	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14105 EA	Aquatic Ecosystem Management	**Elective (Allied)**	2	2	2	**2+1+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14106 EA	Biostatistics and Biotechniques	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14107 EA	Invasion Biology	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14108 EO	Environmental Education	**Elective (Open)**	3	2	0	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Minimum Credits to be obtained=24			**Minimum Contact Hours=31**						
SEMESTER 2nd									
Course Code	Course Name	Category	Hours				Theory		Pract.
			L	T	P	Credits	Ex.	Int.	Int.
Bot-14201 CR	Pteridophyta and Gymnosperms	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14202 CR	Ecology	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14203 CR	Cell and Molecular Biology	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14204 EA	Biodiversity and Conservation Biology	**Elective (Allied)**	2	2	2	**2+1+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14205 EA	Applied Plant Pathology	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14206 EA	Applied Phycology	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14207 EA	Stress Biology	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14208 EO	Commercial Floriculture and Post-	**Elective (Open)**	3	2	0	**3+1=4**	**60(24)**	**15(6)**	**25(10)**

	Harvest Technology of cut flowers								
Minimum Credits to be obtained=24						**Minimum Contact Hours=31**			
SEMESTER 3rd									
Course Code	**Course Name**	**Category**	**Hours**				**Theory**		**Pract.**
			L	**T**	**P**	**Credits**	**Ex.**	**Int.**	**Int.**
Bot-14301 CR	Reproductive and Developmental Biology of Angiosperms	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14302 CR	Cytogenetics and Genetics	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14303 CR	Plant Biochemistry	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14304 EA	Applied Ecology	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14305 EA	Applied Crop Physiology	**Elective (Allied)**	2	2	2	**2+1+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14306 EA	Project Work	**Elective (Allied)**	0	0	16	**8**	**100(40)**		
Bot-14307 EO	Applied Biodiversity	**Elective (Open)**	3	2	0	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Minimum Credits to be obtained=24						**Minimum Contact Hours=31**			
SEMESTER 4th									
Course Code	**Course Name**	**Category**	**Hours**				**Theory**		**Pract.**
			L	**T**	**P**	**Credits**	**Ex.**	**Int.**	
Bot-14401 CR	Plant Physiology	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14402 CR	Plant Tissue Culture and Genetic Engineering	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14403 CR	Plant Resource Utilization	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14405 EA	Plant Systematics and Diversity	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14406 EA	Molecular Ecology	**Elective (Allied)**	2	2	2	**2+1+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14407 EA	Commercial Plant Propagation	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14408	Crop Genetics and	**Elective**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**

EA	Molecular Breeding	**(Allied)**							
Bot-14409 EO	Mushroom Cultivation Technology	**Elective (Open)**	3	2	0	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Minimum Credits to be obtained=24			**Minimum Contact Hours=31**						

SEMESTER 1ST

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Bot-14108 EO	Environmental Education	**Elective (Open)**	3	2	0	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Minimum Credits to be obtained=24			**Minimum Contact Hours=31**						

Bot-14101 CR: PLANT TAXONOMY

Unit: I

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

ii. Approaches to plant classification: 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)

Unit: II

i. Taxonomic characters: kinds (vegetative & reproductive characters) and criteria; taxonomic sources (morphology, cytology, palynology, phytochemistry, molecular biology)

ii. Taxonomic categories & hierarchy: taxonomic categories (supra-specific, species & infra-specific); taxonomic hierarchy (structure & properties)

Unit: III

i. Taxonomic tools & institutions: herbarium (collection, preparation and role); botanic garden (concept & importance); taxonomic literature (flora, monograph, revision, manuals, indices, journals); Botanical Survey of India (organization & role).

ii. Plant identification: methods of identification; types of keys (dichotomous keys - kinds and construction, polyclaves - a brief account); cybertaxonomy (concept & scope)

Unit: IV

i. Scientific nomenclature: overview of various nomenclature codes - Viral, Bacteriological, International Code for Nomenclature of Cultivated Plants (ICNCP), International Code for Nomenclature of algae, fungi and plants (ICN); principles of ICN; biocode and phylocode (an elementary idea).

ii. Practice of nomenclature: type method (concept & kinds); author citation; effective and valid publication; basionyms and synonyms; homonyms; autonyms and tautonyms.

Laboratory Exercises:

1. To prepare a herbarium of different leaf types.
2. To prepare a herbarium of different inflorescence types.
3. To prepare a herbarium of different fruit types.
4. To describe the various botanical families: Ranunculaceae, Brassicaceae, Fabaceae, Rosaceae, Malvaceae, Asteraceae, Apiaceae, Solanaceae, Poaceae, Liliaceae.
5. To study various placentation types.
6. To compare different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

Bot-14102 CR: MICROBIOLOGY, FUNGI AND PLANT PATHOLOGY

Unit: I

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

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

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

Unit: II

i. Viruses: general characteristics; Origin, chemical nature and ultrastructure.

ii. **Replication, tansmission and isolation**: mechanisms of viral replication; difference between DNA and RNA viruses; transmission (ways and vectors); isolation and purification of plant viruses

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

Unit: III

i. Fungi: general characteristics, cellultrastructure; unicellular and multicellular organization; cellwall composition; nutrition (saprobic and biotropic); reproduction (vegetative, asexual and sexual); heterothallism; heterokaryosis, parasexual life cycle; recent trends in classification of fungi

ii. Structural diversity and mode of reproduction: Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina; role of fungi with respect to food and medicine; mycorrhizae-types and role

Unit: IV

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

ii. Symptoms, etiology, epidemiology and control of following plant diseases: paddy blast, powdery mildew of cucurbits, black stem rust, 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

Laboratory Exercises:

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.

Bot-14103 CR: ALGAE AND BRYOPHYTA

Unit: I

i. Algae: diverse habitats (terrestrial, freshwater, marine); thallus organisation; evolutionary relationships; cell ultrastructure; reproduction (vegetative, asexual, sexual); criteria for classification of algae (pigments, reserve food, flagella).

ii. Classification and salient features: Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

Unit: Il

i. Algal blooms: causal factors and dynamics of freshwater algal blooms; physical and chemical means and bio-manipulation (top- down and bottom-up) for controlling nuisance blooms; role of phycoviruses in algal bloom control; algal bio-fouling of ships and its control.

Unit III

i. Liverwort and Hornworts: classification, morphology, anatomy and reproduction of Takakiales; Marchantiales, Jungermanniales (acrogynous and anacrogynous) and Anthocerotales.

ii. Bryphytes in bioindication: direct and indirect biomonitoring**.**

Unit: IV

i. Mosses: classification, morphology, anatomy and reproduction of Funariales, Sphagnales and Polytrichales,

ii. Origin and evolution: gametophyte and sporophyte; economic and ecological importance of bryophytes, symbiotic associations of bryophytes

Laboratory Exercise:

1. Morphological study of the representative members of Algae: *Anabaena, Nostoc, Pediastrum, Volvox, Hydrodictyon, Ulva, Clostridium, Chara, Botrydium, Enteromorpha, Padina, Bulbochaete, Ceramium* and *Batrachospermum*.

2. Study of morphological, anatomical and reproductive structures of various bryophytes viz: *Pellia, Porella, Anthoceros, Polytrichum, Andreaea, Bryum, Mnium* and *Funaria*.

BOT-14104 EA: HERBAL MEDICINE- STATUS AND STRATEGIES

Unit: I

1. History of Herbal medicine: documentary and archaeological evidences supporting the traditional theme

2. Herbal systems of Medicine: world scenario with emphasis on- concept, status and potential at Regional, National and International level:

- ❖ European
- ❖ North American
- ❖ Central and South American
- ❖ African and Middle eastern
- ❖ African
- ❖ Chinese and Tibetan
- ❖ Unani
- ❖ Ayurvedic
- ❖ Sidhi

3. Traditional usage of herbal medicine in Jammu and Kashmir: history, status and potential

Unit: II

1. Diversity and distribution: medicinal plants (MP's) in J & K

2. Different threats: causes and concerns of Kashmir Himalaya

3. Assessment of Population status: MP's of J & K in accordance with IUCN guidelines

4. Data collection: methods, documentation and exchange

5. Importance of threat assessment of MP's

Unit: III

1. Commercial potential: MP's in Kashmir Himalaya

2. Role of MP's: Pharmaceutical Industry

3. Role of Assessment: status of genetic diversity and its role in conservation of MP'S

4. Linkage between traditional knowledge holders, policy makers and Industry: NGO's and their role in commercialization of MP's based on traditional knowledge

Unit: IV

1. Spices and condiments: medicinal aspects in relation to modern theme of herbalism

2. Economic valuation: techniques used to estimate the monetary values and to educate the tribals and locals for facilitating herbal medicine commercialization

3. Bio-prospecting: the systematic search for new sources of chemical compounds, genes, proteins, microorganisms that have potential medicinal value as a biotic resource

4. Traditional knowledge regarding herbal medicine: its impact on benefit sharing

Laboratory Exercise:

1. Studies on MP's of Kashmir with respect to status, distribution pattern, adaptability and threats, if any
2. Survey of various tribal areas of Kashmir valley to compile an inventory of important medicinal plant species of the region (name, local name, part used, uses, method of use, degree of popularity and precautions, if any)
3. Assessment of resource allocation and resource partitioning of important MP's of Kashmir Himalaya
4. Assessment of reproduction biology as a means of domestication and conservation of MP's
5. Analysis of active components in relation to commercial usage of important MP's of Kashmir
6. Developing vegetative and sexual parametres for commercialization of important MP's of Kashmir
7. Preparing a herbarium of atleast 30 important medicinal plants with all detailes related to habit, habitat, density and diversity and status

Bot-14105 EA: AQUATIC ECOSYSTEM MANAGEMENT

Unit: I

i. Structure and function: lakes and wetlands (definition, types and distribution); zonation (principles and patterns); aquatic plants (growth forms and distribution pattern); hydrology, trophic status and nutrient dynamics of lakes and wetlands with special reference to Kashmir Himalaya.

Unit: II

i. Values and valuation: economic goods and ecosystem services (provisioning, regulating, cultural, supporting); valuation of aquatic ecosystems - framework and approaches of valuations, types of values (ecological, socio-cultural, economic).

Unit: III

i. Threats and challenges: threats to lake and wetland ecosystems with special reference to Kashmir Himalaya; biological invasion in lakes and wetlands; aquatic invasive plants (traits and impacts); eutrophication, catchment deterioration; climate change and aquatic ecosystems.

Unit: IV

i. Restoration and Management: ecosystem resilience and stability; restoration strategies (types, merits and demerits); ecosystem approach to management (Ecological perspectives - biotic and abiotic factors; socio-economic perspectives – stakeholders, values and issues, Institutional perspectives); monitoring, prediction and management of invasive aquatic plants.

Laboratory Exercises:

1. Determining dissolved oxygen content in waters drawn from lakes and wetlands
2. Assessment of water quality through B.O.D test.
3. Phytosociological analysis of macrophytic communities in lakes and wetlands.
4. Assessment of water turbidity and sacchi transparency.
5. Valuation of ecosystem services provided by aquatic ecosystems

Bot-14106 EA: BIOSTATISTICS AND BIOTECHNIQUES

Unit: I

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 distributions.

ii. 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

i. 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 experiments.

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

Unit: III

i. Testing of hypothesis: basic concepts, procedure for hypothesis testing; test difference between two means (-independent and paired samples); test of proportions and test of goodness of fit.

ii. Simple correlation and regression: basic idea, scatter diagram, 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

i. Chromatography: principles and applications of paper, thin layer, column chromatography, HPLC, ion exchange, affinity and gas liquid chromatographic techniques;

Electrophoretic and Centrifugation Techniques: gel electrophoresis; ultra centrifugation

ii. Biophysical 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

iii. Radio-labeling Techniques: Properties of different radio-isotopes and their applications in biology, Safety guidelines.

Laboratory Exercises:

1. Collection of raw data on different parameters and classification of ungrouped data into grouped data (discrete and continuous series) i.e. frequency distribution
2. Frequency distribution table and Construction of Simple bar chart, Histogram and Scatter plot.
3. To find the various measures of central tendency (mean, mode and median) of the given data.
4. To find the various measures of dispersion (mean deviation, standard deviation, variance and coefficient of variation) of the given data.
5. Drawing of a sample from a given population by various sampling techniques (simple random, systematic and stratified sampling)
6. To perform One-way ANOVA and Two-way ANOVA of the given data sets.

7. Correlation, linear regression.
8. Gel electrophoresis techniques and analysis.
9. Paper and thin layer (TLC) chromatography.

Bot-14107 EA: INVASION BIOLOGY

Unit: I

i. Introduction to invasion biology: historical perspective of invasion biology, critique of invasion Biology (SPRED ecology – SPecies REDistribution)
ii. Process of invasion: introduction (intentional and accidental), pathways and vectors, rapid evolution, hybridization, biotic resistance, propagule pressure, residence time, tens rule, establishment, naturalization, spread, invasion meltdown

Unit II:

i. Species invasiveness: allelopathy, phenotypic plasticity, escape from enemy, evolution of increased competitive ability, Darwin's naturalization hypothesis
ii. Community invasibility: empty niche hypothesis, diversity–invasion dilemma and predator relationship, intermediate disturbance hypothesis

Unit III

i. Invasions and global environmental change: effect of change in temperature, atmospheric CO_2 concentration, nitrogen deposition, disturbance regimes, and habitat fragmentation on species invasions
ii. Ecological and economic impacts: biotic homogenization, impact of invasions on community structure, trophic levels, nutrient cycling, hydrology and fire regimes, invasion debt and alteration in total economic value (TEV) of biodiversity

Unit: IV

i. Invasion prediction and risk assessment: prediction of invasive species, weed Risk assessment, species distribution modeling (GARP, MaxEnt), quarantine measures
ii. **Management of invasive species**: early detection and rapid response, physical, chemical and biological control (advantages and disadvantages), biological invasions (indicators and policy)

Laboratory Exercise:

1. Determine the stage of invasion of a particular plant species in the given area.

2. Determine allelopathic potential of the given plant species by point quadrat method

3. Demonstrate the effect of leachate of an invasive species on seed germination of a native species

4. Study the abundance of common pests of an invasive plant species

Bot-14108 EO: ENVIRONMENTAL EDUCATION

Unit: I

i. Environment

- definition, principle and scope of environmental Science
- relation between man and environment
- atmosphere: structure and composition
- hydrosphere: global water resources and hydrological cycle
- lithosphere: a brief account
- biosphere: its component

Unit: II

i. Environmentalism

- environmentalism: concept and history
- environmental organizations (WWF, UNEP, IUCN, WHO), summits and protocols
- environmental movements in India – Narmada dam, Tehri dam, Almatti dam and Chipko
- concept of sustainability
- environmental Politics

Unit: III

i. Education

- environmental education
- environmental Protection and religious teachings
- public awareness and role of NGOs
- environmental psychology and current problems
- environmental Ethics

Unit: IV

i. Environmental economics and management

- environmental economics – Definition and Scope
- population, poverty and environment.
- concept of intangibles and externalities
- environmental evaluation methods: Hedonic pricing, Contingent evaluation and household production function.
- carbon credits and trading
- environment Impact Assessment: framework and approaches

Laboratory Exercises

1. Determining dissolved oxygen content in waters drawn from lakes and wetlands
2. Assessment of water quality through B.O.D test.
3. Phytosociological analysis of macrophytic communities in lakes and wetlands.
4. Assessment of water turbidity and sacchi transparency

SEMESTER 2ND

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Bot-14208 EO	Commercial Floriculture and Post-Harvest Technology of cut flowers	**Elective (Open)**	3	2	0	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
SEMESTER 2nd									

Bot-14201 CR: PTERIDOPHYTA AND GYMNOSPERMS

Unit: I

i. Pteridophytes: origin and evolution, telome theory; stelar evolution; classification; economic importance

ii. Fossil Pteridophytes: Structural features and evolutionary significance of *Rhynia, Lepidodendron, Calamites*

Unit :II

i. Diversity, morphology, anatomy and reproduction in: Psilopsida (Psilotales), Lycopsida (Lycopodiales, Selaginellales, Isoetales), Sphenopsida (Equisetales), Ophioglossales, Eusporangiate ferns (Marattiales), Leptosporangiate ferns (Filicales, Marsileales, Salviniales).

Unit: III

i. Gymnosperms: origin and evolution, classification (Sporne, Christenhuez); economic importance; diversity and distribution in India; gymnosperms of J & K state (an overview)

ii. Fossil Gymnosperms: Structural features and evolutionary significance of Pteridospermales, Cycadeoidales, Cordiatales

Unit: IV

i. Diversity, morphology, anatomy and reproduction in: Cycadales, Ginkogoales, Coniferales, Taxales, Ephedrales, Gnetales, Welwitschiales

Laboratory Exercises:

1. Study of morphological, anantomical and reproductive structures of the representative Pteridophytes viz: *Psilotum, Ophioglossum, Dryopteris, Equistem, Marsilea* and *Pteris*.
2. Study of important fossil Pteridophytes from prepared slides.
3. Study of morphological, anatomical and reproductive structures of representative Gymnosperms, such as *Pinus, Cedrus, Abies, Picea, Taxus, Cephalotaxus, Araucaria, Taxodium, Gnetum, Ephedra, Ginkgo, Cycas*.

Bot-14202 CR: ECOLOGY

Unit: I

i. Population ecology: population characteristics; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

ii. Habitat and niche: concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

iii. Species interactions: types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit: II

i. Community ecology: nature of communities; community structure and attributes; species diversity and its measurement, richness and evenness; edges and ecotones; guilds

ii. 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.

iii. Community stability: diversity- disturbance, and diversity stability relationships; ecology of plant invasion- process of invasion.

Unit: III

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

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).

iii. Global bio-geochemical cycles: biogeochemical cycles of C, N, P and S (pathways, processes, budgets and anthropogenic impact)

Unit: IV

i. Diversity Patterns: species abundance distribution, diversity patterns (latitudinal gradient- contributory factors and explanatory theories)

ii. Biogeography: MacArthur and Wilson's island biogeography equilibrium theory-limitations and modifications; colonization vs. extinction; species area relationship

iii. Biomes: types (terrestrial and aquatic), distribution and unique features

Laboratory Exercises:

1. Types of quadrats (sampling units) and their utility.
2. Determination of minimum size and number of quadrats for phytosociological studies.
3. Computation of Frequency, Density, Abundance and Cover of constituent species of different communities.

4. Computation of Relative Frequency, Relative Density, Relative Abundance and Relative Cover of constituent species of different communities.
5. Estimation of IVI of the species in different communities.
6. Estimation of species diversity and dominance.
7. Comparison between protected and unprotected grasslands using community co-efficient

Bot-14203 CR: CELL AND MOLECULAR BIOLOGY

Unit: I

i. Cell wall and plasma membrane: structure and functions; membrane proteins – integral and transmembrane proteins.

ii. The cytoskeleton: organization and role of microtubules and microfilaments, motor proteins.

iii. Nucleus: nuclear membrane and nuclear pore complex, transport of proteins and RNAs across nuclear membrane.

Unit: II

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

ii. Golgi complex and ER: role in protein sorting and transport; lysosomes – endocytosis and phagocytosis.

iii. The cell cycle: phases of cell cycle, regulation of cell cycle progression, role of cyclin and cyclin-dependent kinases.

Unit: III

i. DNA: DNA structure, mechanism of DNA replication, DNA damage and repair mechanisms.

ii. Transcription: RNA polymerase, introns and their significance, transcription factors, mechanism of transcription, major differences between prokaryotes and eukaryotes (at transcriptional level).

iii. RNA processing - Post transcriptional modifications, RNA editing.

Unit: IV

i. Ribosomes - structure and assembly, tRNA and genetic code.

ii. Translation: mechanism of protein synthesis, initiation, elongation and termination factors, major differences between prokaryotes and eukaryotes (at translational level).

iii. Regulation of gene expression: prokaryotes (Lac operon, tryptophan operon) and eukaryotes (role of promoters, activators, repressors and DNA methylation).

Laboratory Exercise:

1. Study of DNA replication mechanism
2. Demonstration of cell cycle, mitosis and meiosis.
3. Identification of different stages of mitosis and meiosis from temporary and permanent slides.
4. Study of morphology of metaphase chromosomes from onion root meristems.
5. Study of various cell organelles using prepared slides and models
6. Cell wall staining with calcoflour
7. Preparation of various types of stains for chromosome analysis.
8. Demonstration of microscopes (Simple compound microscope, phase contrast, fluorescence, SEM).
9. Isolation of plant DNA and its quantification by spectrophotometric method.
10. Plant DNA extraction using standard protocols.

Bot-14204 EA: BIODIVERSITY AND CONSERVATION BIOLOGY

Unit: I

i. Fundamentals of biodiversity: concept of biodiversity (a historical perspective); 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)

ii. Values of biodiversity: direct use, indirect use, option and existence values; ecosystem services; agro-biodiversity (concept and importance); bioprospecting (concept, concerns and scope)

Unit: II

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

Unit: III

i. Conservation strategies: *in situ* conservation strategies (concept of protected areas network); IUCN's scheme of PA management categories; National Parks and Wildlife Sanctuaries in India (an overview); Biosphere Reserve (concept, design and distribution in India); genetic reserves (concept and role); *ex situ* conservation strategies (botanical gardens, field gene banks, seed banks, *in vitro* repositories, cryobanks, DNA banks)

ii. Conservation efforts: global organizations & conventions; Indian conservation efforts: legislations and policies; non-formal conservation efforts.

Unit: IV

i. Conservation biogeography: biogeography (a historical overview); bio-realms (a brief account); endemism (concept and types); biodiversity hotspots (criteria, distribution and conservation implications); phylogeography (an elementary idea);

ii. Measurement of biodiversity: sampling unit – shape, size and number, issue of scale; phylogenetic and functional diversity (concept and applications); biodiversity surrogates (types and use); role of remote sensing and GIS in biodiversity assessment and monitoring

Laboratory Exercise:

1. To prepare an inventory of RET (Rare, Endangered and Threatened plants) in KUBG.
2. Measurement of species diversity by using various biodiversity indices.
3. Measurement of species evenness and similarity index.
4. Measurement of alpha, beta and gamma diversity.
5. Field demonstration of GPS (Global Positioning System) and its utility in biodiversity studies.
6. Study of various economically and ethno-botanically important plants of Kashmir Himalaya
7. Field study of various threatened endemic plants of Kashmir Himalaya.
8. Field demonstration of in situ and ex situ conservation strategies through visit to the national parks, sanctuaries, botanical garden, herbaria, zoos, museums.

Bot-14205 EA: APPLIED PLANT PATHOLOGY

Unit: I

i. Pathogenecity and nature of disease: pathogens and pathogenesis. Kochs postulates, disease: definition and classification; mode of development: inoculum and inoculation, penetration and colonization of pathogen within infected plant

ii. Plant disease epidemiology: elements of plant disease epidemics, host factors and pathogen factors affecting epiphytotic development; diseases forecasting in plant epidemics, examples of disese forcasting system and farmers warning system

Unit: II

i. Pathogens attack on host: role of enzymes and toxins in pathogenesis; aflatoxins, major types and their importance

ii. Plant defense against pathogens: structural or morphological defense and metabolic or biochemical defence induced by attaching pathogens; Phytoalexins

Unit: III

i. Plant diseases: symptomology of fungal and bacterial infections of plants; fungal diseases: symptoms, etiology and control of club root of crucifers, *Rhizopus* rot of fruits and vegetables, loose smut of wheat; bacterial disease: general characteristics; etiology and control of citrus canker, fire blight of apples and pears

ii. Viral and viroid disease: general characteristics of viruses; cucumber mosaic virus, cauliflower mosaic virus, potato spindle tuber; nematodes disease: general characteristics of plant-parasitic nematodes; symptoms, biology and control of root knot disease of plants, ufra disease of rice: mycoplasma diseases: general characteristics of MLO´S; Symptoms, causal organism and transmission of sandle spike disease

Unit: IV

i. Pest management: regulatory methods: quarantine and inspection; physical methods; c chemical methods: types of chemicals, inorganic and organic chemicals, antibiotics

ii. Biological methods: use of fungi, bacteria, entomopathogenic nematodes, organic amendments and antagonistic plants as biocontrol agents; biopesticides, types, advantages and limitations, role in sustainable agriculture, general concept of integrated pest management (IPM) in disease control

Laboratory Exercises:

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

Bot-14206 EA: APPLIED PHYCOLOGY

Unit: I

i. **Algal Biomass**: Monod and Droop models of nutrient-regulated phytoplankton growth; culture and cultivation of economically important freshwater algae; mass cultivation of cyanobacteria under outdoor and indoor conditions.

Unit: II

i. Algal Bio fuels and Bio fertilizers: methane and hydrogen production; Energy and chemicals; Hydrogen production by cyanobacteria: Mechanism, progress and prospects; Cyanobacteria as bio fertilizer for paddy cultivation, reclamation of usar lands.

Unit: III

i. Algae and pollution: eutrophication, algae as indicator of pollution; atmospheric algae; high rate algal ponds for the treatment of waste waters and sewage and an alternative source for the production of useful biomass and energy .

Unit: 1V

i. Economic Importance of Algae: algae as a source of food and fodder; algal polysaccharides (agar agar, carageenan and alginic acid); algae in pharmaceutical industries; immobolized and inactivated algal biomass for metal and nutrient removal.

Laboratory Exercise:

1. Preparation of temporary mounts and Identification of phytoplankton belonging to different classes of algae
2. Culture of some economically important algae
3. Cultivation of cyanobactaria under indoor conditions

Bot-14207 EA: STRESS BIOLOGY

Unit: I

i. Stress: abiotic and abiotic stress – overview; ion homeostasis: essential components of homeostatis; water balance and regulation of stomatal movements; osmotic adjustments: osmolytes and their types; regulation of osmolyte concentration, mechanism if osmolyte action; reactive oxygen species and oxidative stress in plants: ROS production, ROS scavenging, enzymatic antioxidants, non-enzymatic antioxidants

Unit: II

i. Genomics of stress tolerance in plants: functional genomic approaches role in elucidating abiotic stress tolerance mechanisms; transcriptome analysis; transcript populations and transcript profiling; Role of transcription factors; DREB, dehydration-responsive element (DRE) binding protein; DREB/CBF regulon; role miRNAs in stress; protein profiling; late embryogenesis proteins (LEA), heat shock proteins, dehydrins, antifreeze proteins, etc.

Unit: III

i. Stress signaling in plants: calcium signaling: role calcium, calmodulin and other calcium binding proteins; signaling through mitogen activated protein kinases; nitric oxide; biosynthesis of NO and role in signaling; sugars as signaling molecules; ABA mediated signaling pathway

Unit: IV

i. Bioengineering plants for stress tolerance: transgenic approaches for improved stress tolerance: arabidopsis as a model system; adoption of GM crops; future challenges in agriculture; GM strategies for insect resistance, glyphosate tolerance – case studies; RNAi – role in pest and disease management; applied biotechnology: interacting factors in molecular breeding for crop tolerance

Laboratory Exercise:

1. Estimation of changes in amino acids response to cold stress

2. Changes in superoxide dismutase in response to salt stress
3. Changes in catalase in response to abiotic stress
4. Changes in polyamine levels in response to fungal stress
5. Changes in ascorbate peroxidase in response to heat stress
6. Changes in glutathione reductase in response to drought stress
7. Changes in protein in response to biotic stress by SDS- PAGE
8. Changes in protein levels in response to cold stress by SDS-PAGE

Bot-14208 EO: COMMERCIAL FLORICULTURE AND POST HARVEST TECHNOLOGY OF CUT FLOWERS

Unit: I

i. Floriculture industry: global floriculture (International scenario and trade); floriculture in India; lifestyle horticulture (hi-tech floriculture; cut flowers, loose flowers, foliage plants, bedding plants, potted plants, bulbous plants, landscape plants, flower seed production, nursery industry, strategies for growth and cultivation of flowering/ornamental plants). floriculture for improving the environment and quality of life.

Unit: II

i. Pre and Postharvest approaches in cut flower industry: factors affecting pre and postharvest quality of cut flowers; stage, time and mode of harvest of cut flowers; role of temperature, light, humidity and moisture on postharvest performance of cut flowers.

Unit: III

i. Postharvest storage of cut flowers: dry and wet storage of cut flowers; controlled atmospheric storage (CAS); modified atmospheric storage (MAS); low pressure storage (LPS); role of refrigeration/ cold chain, rehydration and pulsing during storage.

Unit: IV

i. Packaging, Transportation and Marketing of cut flowers: packaging for efficient transportation; simulation of transportation protocols; consumer preferences; marketing practices; techniques for improving longevity/ vase life of cut flowers.

Laboratory Exercise: Project Work

SEMESTER 3RD

Course Code	Course Name	Category	Hours				Theory		Pract.
			L	T	P	Credits	Ex.	Int.	Int.
Bot-14301 CR	Reproductive and Developmental Biology of Angiosperms	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14302 CR	Cytogenetics and Genetics	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14303 CR	Plant Biochemistry	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14304 EA	Applied Ecology	**Elective (Allied)**	3	0	2	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14305 EA	Applied Crop Physiology	**Elective (Allied)**	2	2	2	**2+1+1= 4**	**60(24)**	**15(6)**	**25(10)**
Bot-14306 EA	Project Work	**Elective (Allied)**	0	0	16	**8**	**100(40)**		
Bot-14307 EO	Applied Biodiversity	**Elective (Open)**	3	2	0	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
SEMESTER 3rd									

Bot-14301 CR: REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY OF ANGIOSPERMS

Unit: I

i. Flower development: induction and evocation, floral organ development, flowering in perennials, seasonal flowering, polycarpy and biennial bearing.

ii. Male and female gametophyte: structure of anther, role of tapetum, Microsporogenesis and development of pollen, regulation of asymmetric first pollen

mitosis, control of second pollen mitosis and sperm cell differentiation Female gametophyte development: initiation, patterning, cell fate specification and maintenance of cell identities of female gametophyte.

Unit: II

i. 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, pollen tube growth and guidance, double fertilization

ii. Seed development, fruit growth and dormancy: endosperm development, embryogenesis- landmarks of embryo pattern formation, polyembryony and apomixes, dynamics of fruit growth, importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.

Unit: III

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

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

iii. 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

Unit: IV

i. Patterns in plant development: growth, differentiation and development, genetic control and hormonal regulation of development, physiology of hormones in plant development.

ii. Shoot development: organization of the shoot apical meristem (SAM); cytological and 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

iii. Wood development in relation to environmental factors.

Laboratory Exercise:

1. Study of living shoot apex of *Hydrilla*
2. Study of cytological zonation in the shoot apical meristem in double stained permanent slides of any suitable plant.

3. Study of different leaf arrangements
4. Study of C. S. of typical dicot and monocot leaves
5. Study of epidermal peels of leaves of appropriate to study various stomatal types
6. Study of anatomy of dicot and monoct roots and stems using appropriate materials
7. Study of microsporogenesis and gametogenesis in appropriate materials
8. Estimation of pollen germination and average pollen tube length *in vitro*
9. Study of different types of ovules, embryo sacs through examination of permanent slides
9. Isolation of monocot and dicot embryos from suitable materials

Bot-14302 CR: CYTOGENETICS AND GENETICS

Unit: I

i. Chromosomes: chromosome structure, chromatin organization, nuclear DNA content and c-Value paradox, repetitive DNA - types and utility.

ii. Molecular organization: centromere and telomere; euchromatin and heterochromatin, chromosome banding techniques (Q, C and G) and their utility.

iii. Concept of split genes: overlapping genes and pseudo genes.

Unit: II

i. Karyotype: concept, essential features and evolution of karyotype;

ii. B chromosomes: origin, characteristics and distribution of B- chromosomes

iii. Structural heterozygotes: origin, meiosis and breeding behavior of deletion, duplication, inversion and translocation heterozygotes, robertsonian translocation, B-A translocation.

Unit: III

i. Euploidy: types, origin, meiosis and breeding behaviour of autopolyploids, chromosome and chromatid segregation in autopolyploids, role of autopolyploids in crop improvement, origin and production of allopolyploids, role of allopolyploidy in evolution of crop plants.

ii. Aneuploidy: types of aneuploids, origin, meiosis and breeding behaviour of aneuploids.

Unit: IV

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

ii. DNA recombination: molecular mechanism of recombination, multigene families and their evolution, in-situ hybridization techniques (FISH, GISH), flow cytometry (concept and utility), population genetics (brief idea),

iii. Mutations: types of Point mutations, molecular basis of gene mutation.

Laboratory Exercise:

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. Induction of polyploidy using colchicine in different ways.
7. Study of PMC-meiosis in different materials.
8. Karyotype analysis and preparation of kario-idiogram.

Bot-14303 CR: PLANT BIOCHEMISTRY

Unit: I

i. Principles of Bioenergetics: bioenergetics and thermodynamics; concept of free energy; biological oxidation-reduction reactions- redox potential and free energy; phosphoryl group transfer and ATP.

ii. Enzymes: kinetics of single-substrate enzyme catalyzed reactions- Michaelis-Menton equation and its significance; enzyme inhibition and mechanism of enzyme catalysis; extraction and purification of proteins (brief account).

Unit: II

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

Unit: III

i. 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

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

Laboratory Exercise:

1. Estimation of reducing sugars in a sample by titrimetric method.
2. Estimation of total titrable acidity in the plant material.
3. Determination of saponification value of a given fat or oil.
4. 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.
5. To study the effect of substrate concentration on the activity of enzyme and determination of its Km value.
6. Study of enzyme kinetics with respect to the effect of pH.
7. Extraction and separation of chloroplast pigments in the plant material by partitioning into different solvent systems.
8. Separation of chloroplast pigments by thin layer chromatography.
9. Determination of rate of photosynthesis in an aquatic plant by Winkler's method.
10. Determination of succinate dehydrogenase activity.
11. To study principles of colorimetry and spectrophotometry.
12. Extraction of chloroplast pigments from leaves and preparation of absorption spectrum of photosynthetic pigments and anthocyanins.
13. Determination of activity of polyphenol oxidase and peroxidase.

Bot-14304 EA: APPLIED ECOLOGY

Unit: I

i. Applied microbial ecology: bioremediation (principles, factors and strategies); microbes and organic pollution; microorganisms and metal pollution

ii. Microbes and waste management: microorganisms and wastewater treatment; commercial blends of microbes and enzymes in wastewater treatment; role of microbes in solid waste management

iii. Microbes and environmental monitoring: biosensors (types and role in pollution monitoring); microbes as bio-indicators, standards and criteria for indicators

Unit: II

i. Global climate change: Climate change (causes and consequences); greenhouse gases- sources, trends and role; global warming, CO_2 fertilization

ii. Environmental pollution: Kinds and sources of pollutants; impact of SO2 on plants; eutrophication of aquatic ecosystems- sources and impacts

iii. Ozone depletion: Ozone hole; UV radiation and their impact, response of plants to tropospheric ozone acid precipitation- components and impacts

Unit: III

i. Ecosystem management: nature of environmental problems and societal response; environmental impact assessment (EIA) conceptual framework, contents, methodology and role in environmental conservation- and of EIA

ii. Restoration ecology: concept, concerns, strategies and planning; biodiversity-ecosystem function relationship (BEF)

iii. Sustainable development: concept of sustainable development and indicators of sustainability

Unit: IV

i. Phytoremediation: process of phytoremediation (phytoextraction, phytostabilization, phytotransformation) ; applications of phytoremediation

ii. Climate change mitigations: methods and means, costs and benefits, international treaties and strategies

iii. Environmental ethics: introduction to environmental ethics; ecological footprint analysis (an overview); traditional ecological knowledge (context, practices and challenges)

Laboratory Course:

1. To determine the soil texture, aggregate stability, porosity and bulk density of various soil samples collected from different sites
2. To determine the moisture content and water holding capacity of soil samples collected from different locations

3. To find out the percentage organic carbon and organic matter content in soils of cropland, grassland and forest
4. To determine the carbon stock in different plant systems
5. To estimate the dissolved oxygen content in different water samples
6. To use the BOD test for assessment of the level of organic pollution in water samples

Bot-14305 EA: APPLIED CROP PHYSIOLOGY

Unit: I

i. Water relations and mineral nutrition: Movement of water through soil-plant-atmosphere continuum; Stomatal transpiration, Role of transpiration; Water use efficiency and crop productivity; Availability of ions in soil, Absorption and assimilation of mineral nutrients (N, P and K) by crops; Plant nutrient responses.

Unit: II

i. Photosynthesis and crop productivity: 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 in crop plants.

Unit: III

i. Growth analysis and crop yield: Principles and practices of plant growth analysis; Concepts & computation of 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) and Specific leaf area (SLA); Dry matter partitioning into various parts of plant and its impact on source-sink relationship; Relation between growth and yield (Harvest index).

Unit: IV

i. Chemical control of plant growth: Role of plant growth regulators (PGRs) (auxins, gibberellins, cytokinins, ethylene and growth retardants) in agriculture and horticulture.

Laboratory Course:

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.

4. 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)

5. Separation of proteins by polyacrylamide gel electrophoresis (PAGE)

6. Study of the physiological effects of the following growth regulators:
i.) auxins ii.) gibberellins iii.) cytokinins

Bot-14306 EA: PROJECT WORK

Project work worth 8credits is compulsory for the students and will be assigned in 3rd semester based on choice of the student and space availability in relation to his/her choice as well as choice of the teacher's concerned. The project has to be submitted prior to the conduct of 4th semester examination so that it can be evaluated and viva voce be conducted prior to declaration of the results.

Bot-14307 EO: APPLIED BIODIVERSITY

Unit: I

i. Biodiversity Science: concept of biodiversity (a historical account); components and levels of biodiversity; cultural diversity; magnitude of biodiversity (global, India and J & K state overview); mega-diverse countries; global biodiversity hotspots; values of biodiversity; ecosystem services (concept and kinds); agro-biodiversity (concept and importance);

Unit: II

i. Threats & Conservation: threats to biodiversity (habitat loss, alien invasion, overexploitation, climate change); the IUCN Redlist of Threatened species; threatened ecosystems (wetlands, grasslands, forests, alpine ecosystems with particular reference to Kashmir Himalaya); conservation strategies (*In-situ* & *ex-situ*)

Unit: III

i. Biodiversity policy: Intergovernmental Platform on Biodiversity & Ecosystem Services (IPBES); Reducing Emissions from Forest Degradation & Deforestation (REDD); The Economics of Ecosystem Services & Biodiversity (TEEB); Green Economy; Natural Capital; Political Ecology

Unit: IV

i. Biodiversity conventions & legislations: Convention on Biological Diversity (CBD), Ramsar Convention, CITES; National Biodiversity Act, 2002; conservation efforts in India (National Biodiversity Authority, State Biodiversity Boards, People's Biodiversity Register).

Tutorial

SEMESTER 4TH

SEMESTER 4th									
Course Code	Course Name	Category	Hours				Theory		Pract.
			L	T	P	Credits	Ex.	Int.	
Bot-14401 CR	Plant Physiology	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14402 CR	Plant Tissue Culture and Genetic Engineering	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14403 CR	Plant Resource Utilization	**Core**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14404 EA	Plant Systematics and Diversity	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14405 EA	Molecular Ecology	**Elective (Allied)**	2	2	2	**2+1+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14406 EA	Commercial Plant Propagation	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14407 EA	Crop Genetics and Molecular Breeding	**Elective (Allied)**	3	0	2	**3+1=4**	**60(24)**	**15(6)**	**25(10)**
Bot-14408 EO	Mushroom Cultivation Technology	**Elective (Open)**	3	2	0	**3+1= 4**	**60(24)**	**15(6)**	**25(10)**
Minimum Credits to be obtained=24			**Minimum Contact Hours=31**						

Bot-14401 CR: PLANT PHYSIOLOGY

Unit: I

i. Membrane transport, Translocation of water and solutes: Plant water relations (water potential and its components); Mechanism of water transport through xylem; Root–microbe interactions in facilitating nutrient uptake; Phloem transport; Phloem loading and unloading; Membrane transporter proteins and processes.

Unit: II

i. Signal transduction: General concept; Diversity in protein kinases and phosphatases; Heterotrimeric G-protein complex; Phospholipid signaling; Calcium-mediated signaling; Annexins; CyclicAMP (cAMP); Specific signaling mechanisms (two component sensor-regulator system in bacteria and plants); Sugar-sensing and signaling in plants (hexose, sucrose and trehalose signaling).

Unit: III

i. Plant Photoreceptors: Light-oxygen-voltage "LOV" sensors, Xanthopsins, Phytochromes, Blue-light sensors using flavin adenine dinucleotide "BLUF", Cryptochromes and Rhodopsins (A brief overview). Phytochromes and Cryptochromes: Discovery, Structure, Photochemical and biochemical properties, Cellular localization and responses.

Unit: IV

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

ii. The control of flowering: floral evocation (internal and external cues), Endogenous clock and its regulation; Photoperiodic control of flowering; Vernalization and its significance.

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Laboratory Course:

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 Q10 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.

Bot-14402 CR: PLANT CELL TISSUE AND ORGAN CULTURE AND GENETIC ENGINEERING

Unit: I

i. Plant tissue culture: introduction, historical perspective and scope; cellular totipotency: concept, cytodifferentiation and its mechanism; organogenic differentiation

ii. Cell culture and cell cloning: isolation of single cells from plant organs and cultured tissues; suspension cultures: types, synchronization, factors affecting culture of single cells; Bergmann's cell plating technique

iii. Haploids: androgenic and gynogenic; Anther culture: factors affecting androgenesis, ontogeny of androgenic haploids, applications of haploids in plant breeding.

Unit: II

i. Somaclonal and gametoclonal variations: origin, induction and selection of variants; achievements and prospects.

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

iii. Industrial applications and germplasm conservation: production of secondary metabolites and their applications, hairy root cultures and bioreactors; cryopreservation of plant cells and organs, short term and long term storage.

Unit: III

i. Recombinant DNA technology: gene cloning principles, restriction enzymes characteristics and utility, cloning vehicles and their properties (plasmids, phages, phagemids and cosmids), artificial chromosomes (YAC), construction of recombinant DNA.

ii. Isolation of gene of interest - gel electrophoresis, southern blotting, genomic and cDNA libraries, bacterial transformation and selection of recombinants, Polymerase chain reaction (PCR) – principle, technique and applications.

Unit: IV

i. DNA sequencing methods, molecular markers (RAPD, AFLP, SSR & SNP) – concept and utility.

ii. Genetic engineering of plants: agrobacterium the natural genetic engineer, Ti plasmids, mechanism of gene transfer, applications of transgenic plants.

iii. Direct methods of gene transfer (electroporation and biolistics), biosafety - possible ecological risks and ethical concerns of GM crops.

iv. Genomics and proteomics: concept and applications, microarray technology and its applications. Brief account of gene silencing; antisense RNA technology and RNA interference (RNAi).

Laboratory Exercise:

1. Washing and sterilization of glassware.
2. 17. Sterilization of growth media.
3. 18. Sterilization of various types of plant materials.
4. 19. Aseptic inoculations under laminar airflow hood.
5. 20. Composition and preparation of plant tissue culture medium.
6. Techniques for establishment of callus cultures and study of different types of calli viz. Compact, friable and nodular types.
7. Establishment of zygotic embryo cultures.
8. In vitro differentiation of roots and shoots in suitable explants.
9. Demonstration of rhizogenesis in *Glycine max*.
10. DNA extraction protocol 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, SSR and AFLP analysis.
14. Isolation of gene of interest using genomic and cDNA library.
15. Demonstration of PCR, centrifuge, deep freezer, and gel electrophoresis apparatus. Gel electrophoresis techniques and analysis

Bot-14403 CR: PLANT RESOURCE UTILIZATION

Unit I

i. Plant Biodiversity: concept, utilization and concerns

ii. Ethnobotany and archaeo-ethnobotany: concept, scope, and role in tracing origin and evolution of domesticated plants.

iii. Origin of Agriculture: time and place of origin, archaeological and other evidences

iv. World Centres of origin and domestication of cultivated plants: Vavilov's and de Candolle's concept, centres and non-centres, secondary centres, plant introduction

Unit: II

i. Green revolution: concept, concerns, benefits and adverse consequences.

ii. Origin, evolution, domestication and uses of:

- **Food plants**- maize, Buckhwheat
- **Fodder**- alfalfa
- **Fibre plants**-Cotton
- **Spices**- saffron
- **Legumes** as sources of food
- **Oil yielding plants**- mustard and groundnut

Unit: III

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

ii. Sugars and Starch: origin, evolution, domestication, extraction and utilization of cane sugar and beet sugar; general account of starch yielding plants.

iii. Rubber: origin, distribution, production, extraction, processing and utilization of rubber.

iv. Paper making: sources of raw material and processing of paper

Unit: IV

i. Agricultural innovation for meeting food demands: agricultural bio-technology, synthetic crops, agriculture in arid zones.

ii. Psychoactive drugs: sources, chemistry of action, use and misuse of *Papaver somniferum* and *Cannabis sativa*

iii. General account of NWFP's: paper, gums, resins, tannins, dyes, bamboo, rattans.

iv. Rosaceous fruits of Kashmir: general account, botany and uses with special reference to apple, pear, plum, cherry, almond and apricot.

Laboratory Exercise:

1. To study the morphology of the part used of various representative crops like rice, wheat, maize, potato, pulses and fruits
2. Study of viability of various crop seeds using germination and T.Z Test
3. Study of seed vigour using standard methods
4. Study of source spice and condiments (source, part used, active components)
5. Study of any five important fodder and forage crops
6. Study of various types of fibres viz. cotton. coir, hemp etc.
7. Morphology, microscospic study of oil yielding tissues and test for oil (mustard, groundnut, soybean, linseed, coconut, sunflower, castor, sesame and cashew nut)
8. Study of comparative characteristics of the grains of cereals, millets and pulses.

9. Study of food reserves in different food crops using microchemical tests.

10. Study of methods of cultivation, processing and uses of various rosaceous fruits of Kashmir

11. Study of ethnobotanical aspects of various local products.

Bot-14404 EA: PLANT SYSTEMATICS AND DIVERSITY

Unit: I

i. Plant systematics and biodiversity: taxonomy, systematics and biosystematics, 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

i. Systematics as a synthetic field: population biology (sources and kinds of variation); ecotypes (origin, types and taxonomic treatment); plant breeding systems (types and their taxonomic significance); pollination biology (modes of pollination, co-evolution between plants and pollinators); hybridization and its role in plant evolution, isolating mechanisms (pre-mating and post-mating); process of speciation (allopatric, parapatric and sympatric); an overview of major species concepts

Unit: III

i. Molecular systematics: sources of DNA-based characters (mitochondrial, chloroplast and nuclear genomes); use of molecular markers in plant systematics citing relevant examples; DNA barcoding (concept, applications and limitations)

ii. Biodiversity informatics: concept and applications; global initiatives - Global Biodiversity Information Facility (GBIF), Encyclopedia of Life (EoL); Biodiversity Heritage Library (BHL), International Plant Names Index (IPNI), e-floras and e-herbaria.

Unit: IV

i. Plant diversity in India: present status and conservation concerns; biogeographical classification of India; forest types of India; Global Biodiversity Hotspots in India (Himalayas, Western Ghats, Indo-Burma, Sundaland)

ii. Plant diversity in Kashmir Himalaya: present status and utilization, current threats and conservation needs

Laboratory Exercise:

1. Herbarium (each student has to prepare a herbarium comprising of at least 50 plant specimens from their area of residence).
2. To study pollination mechanisms in some suitable plants
3. Demonstration on various internet resources on plant systematics and diversity.
4. To describe the plant species by using a comprehensive morphological character list.
5. To draw the illustration of various plant parts, such as whole plant, leaves, whole flower, flower parts etc.
6. To determine the synonymy of plant taxa by using taxonomic literature.
7. To study inter-population, inter-specific, inter-generic character variation.
8. To study the floral morphology of suitable plant species showing different sex types.
9. To study cleistogamy and heterostyly in some suitable plants

Bot-14405 EA: MOLECULAR ECOLOGY

Unit: I

i. **Introduction:** introduction, definition and genesis; applications, limitations and scope; evolutionary perspective.

ii. Molecular identification and characterization: role of molecular characters in taxonomic delimitation; molecular methods of identification – an overview; DNA barcoding (concept, criteria and applications);

Unit: II

i. Microbial ecology and genomics: microbial diversity assessment (culture-dependent and culture-independent approaches), ribosomal genes and genetic profiling of microbial communities; lessons from microbial genomes (structural genomics, functional genomics), microbial metagenomics.

Unit: III

i. Molecular microbial ecology: molecular ecology of rhizosphere organisms; role of natural and genetically modified microorganisms in pollution monitoring and abatement; bio-reporter systems in relation to environmental assessment; microbes and ecological restoration.

ii. Molecular markers in ecology: types of molecular markers (co-dominant markers and dominant markers).

Unit: IV

i. Conservation genetics: Genetic diversity in natural populations; effective population size and metapopulations; role of molecular genetics in plant conservation.

ii. Phylogeography: Phylogeography - concept and scope; applications of phylogeography in determining species natural range, finding the source populations of introduced species.

Laboratory Exercise:

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
9. Quantification of DNA content
10. Use of molecular markers such as RFLP, RAPD
11. Analysis of the RFLP pattern for identification of Operational Taxonomic Units
12. Inference of evolutionary histories from molecular data
13. Estimation of degree of relatedness from molecular data or allele frequencies
14. Calculation of allele frequencies from phenotypic data
15. Estimation of Hardy-Wienberg equilibrium
16. Determining the effective population size
17. Assessment of genetic distance

Bot-14406 EA: COMMERCIAL PLANT PROPAGATION

Unit: I

i. Sexual propagation

- **Seed production and storage**: breeder seed, foundation seed, registered seed, certified seed; seed storage and viability tests: cut test, float test, X-ray photographs
- **Seed germination and dormancy**: germination tests (tetrazolium and excised embryo test), environmental factors influencing seed germination; types and methods of overcoming seed dormancy

Unit: II

i. Vegetative propagation

- **Propagation by cuttings, grafting and budding**: stem cuttings, leaf cuttings, leaf bud cuttings, root cuttings, factors influencing the rooting of cuttings; grafting types, graft incompatibility, effect of rootstock on growth and development of the scion cultivar
- **Propagation by layering and other plant structures**: layering types: tip layering, simple layering, mound layering, air layering; propagation by- runners, suckers, crowns, bulbs, corms, stem tubers, tuberous roots, rhizomes.

Unit: III

i. Micropropagation

- **Zygotic embryo culture**: excision of embryo, embryo-nurse endosperm transplant, Production of rare hybrids, shortening of the breeding cycle.
- **Somatic embryogenesis**: induction, development and maturation of somatic Embryos, synchronization of somatic embryo development, methods and types of synthetic seed production

Unit: IV

i. Clonal propagation: Introduction, Orchid propagation, general techniques of micropragation, factors affecting in vitro stages of microprogation, applications of micropropagation

ii. Production of virus free plants: introduction, virus elimination by meristem-tip culture. factors affecting virus eradication by meristem-tip culture, virus eradication through callus culture; virus indexing

Laboratory Exercise:

1. Assessment of viability of seeds by various tests
2. Practical demonstration of various grafting types
3. Practical demonstration of various layering types
4. Study of monocot and dicot embryos
5. Study of somatic embryos from permanent mounts
6. Practical demonstration of tissues culture techniques

Bot-14407 EA: CROP GENETICS AND MOLECULAR BREEDING

Unit: I

i. Aims and objectives of plant breeding: concept of germplasm and gene pool, mechanisms promoting self and cross pollination, genetic and cytoplasmic male sterility; self incompatibility - types, genetics and utility.

ii. Methods of crop improvement in self pollinated crops: Genetic composition of self-pollinated crops, progeny test, pureline theory, mass selection, pureline selection, backcross method, merits and demerits, achievements.

Unit: II

i. Methods of crop improvement in cross pollinated crops: genetic composition of cross pollinated crops, heterosis and inbreeding depression - genetic basis.

ii. Population improvement method - progeny selection (ear to row method), recurrent selection for general and specific combining ability, production of hybrid varieties - concept and utility, wide hybridization and its utility in crop improvement.

iii. Quantitative traits: polygenic inheritance and role of environment.

Unit: III

i. Molecular breeding: Concept and development of transgenics, transplastomic plants – applications and limitations, reporter genes for detection of transgenic plants.

ii. Applications of transgenic plants in crop improvement (disease and insect resistance, drought tolerance, nutritional quality, male sterility, edible vaccines, golden rice)

iii. Biosafety: Ecological risks and ethical concerns of genetically modified crops.

Unit: IV

i. Molecular markers: types and utility of molecular markers in genetic diversity analysis in crop plants,

ii. Molecular mapping and tagging of agronomically important traits, marker assisted selection in crop plants, marker assisted back cross breeding,

iii. QTL mapping and its applications in crop plants, concept of gene synteny and gene pyramiding.

Laboratory Exercise:

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 favour inbreeding and out breeding.
4. Mitotic chromosome analysis using suitable plant material (onion)
5. Meiotic chromosome analysis using suitable plant material.

6. Induction of polyploidy by colchicines treatment.
7. Karyotype analysis and preparation of kario-idiogram.
8. Analysis of pollen to ovule ratio as an index of the nature of breeding system in some crops.
9. Study of different chromosomal aberrations and their effect on fertility.
10. Restriction digest analysis, RAPD and SSR analysis.

Bot-14408 EO: MUSHROOM CULTIVATION TECHNOLOGY

Unit: I

i. Mushroom: Introduction; general morphology of mushrooms; magnitude of mushroom species; mushroombiology: components of applied mushroom biology: mushroom science, mushroom biotechnology and mushroom mycorestoration

ii. Nutritional and medicinal value of mushrooms: poisonous and non-poisonous mushrooms; edible mushrooms and cultivation in India and world; mushroom production and consumption; world mushroom development industry movements

Unit: II

i. Mushroom cultivation technology: steps in mushroom cultivation: compost , materials used in composting and different formulation used in composting; compost preparation, methods of compost preparation

ii. Spawn: definition, kinds of spawn, spawning and spawning technique, spawn running, post spawning management and handling during spawn running;

Unit: III

i. Casing: raw materials used for casing, preparation and sterilization of casing materials, qualities of an ideal casing material, care after casing, mushroom crop management: management at different stages of crop

ii. Pests and pathogens of mushrooms and their management: general account; important sanitation during various stages of mushroom cultivation

Unit: IV

i. Cultivation of important mushrooms: general process for the cultivation of the white mushroom (*Agaricus bisporus*), and the oyster mushroom (*Pleurotus sajor-caju*)

ii. Medicinal mushrooms: general process for the cultivation of *Lentinus* sp. and *Ganoderma lucidium;* harvesting, post harvest handling and preservation of mushrooms, storage and marketing of mushrooms

Laboratory Exercise:

1. Morphological studies and identification of the local mushroom flora and of preserved specimen of mushrooms
2. Sterilization of media and glass ware, preparation of culture of some local mushroom fungal species
3. Preparation of culture media/substrate: Potato dextrose agar(PDA), Rice bran medium, Richard's solution, Grain spawn substrate, Sawdust spawn substrate, preparation of Agar slants
4. Preparation of different types of compost and some compost formulations.
5. Preparation of different types of spawns
6. Cultivation procedures for Button mushroom and Oyster mushroom
7. Picking and haunting of Mushrooms.
8. Study of fungal pathogens and nematode pests of mushrooms

Suggested Readings:

BOT-01 CR: PLANT TAXONOMY, BOT-27 EA: PLANT SYSTEMATICS AND DIVERSITY AND BOT-23 EO: APPLIED BIODIVERSITY

1. Singh, G. 2004. Plant Systematics: An Integrated Approach. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
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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.
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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.
10. Hills, D.M., Mortiz, C. and Mable, B.K. 1996. Molecular Systematics. Sinnauer, Sunderland, USA.

11. Lomolino, M.V., Riddle, B.R. and Brown, J.H. 2006. Biogeography. Sinnaeur, Sunderland, USA.

12. Singh, G. 2012. Plant Systematics: An Integrated Approach. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

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BOT-02 CR: MICROBIOLOGY, 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

9. Webster, John and Weber Roland .2006. Introduction to fungi. Cambridge University Press

10. Roger and Hull. 2002. Mathew"s Plant Pathology. Acedemic Press

BOT-03 CR ALGAE AND BRYOPHYTA AND BOT-09 PTERIDOPHYTA AND GYMNOSPERMS

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.
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8. Rashid, A. An Introduction to Pteridophyta. Vikas Publishers N. Delhi
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18. Beck, C. B. 1988.Origin and evolution of gymnosperms. Columbia University Press.
19. Singh, V. P. 2006. Gymnosperm (naked Seeds Plant).Sarup and Sons, New Delhi.

BOT-06 EA: BIOSTATISTICS AND BIOTECHNIQUES

1. Bailey, N.T.J. 1994. Statistical methods in Biology. Cambridge University Press, UK.
2. Chainy, G.B.N., Mishra, G. and Mohanty, P.K. 2005. Biostatistics. Oscar Publications India, Ltd.
3. Forthofer, R. N., Lee, E. S. and Hernandez, M. 2006. Biostatistics: A guide to design, analysis and discovery. Academic Press, London.
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13. Westermeier, R. 2001. Electrophoresis in Practice. Wiley-VCH

BOT-05 EA AQUATIC ECOSYSTEM MANAGEMENT AND BOT—08 EO ENVIRONMENTAL EDUCATION

1. Dobson, M., Frid, C (2009) Ecology of Aquatic Systems**.** Oxford University Press
2. Paul A Keddy (2010) Wetland Ecology: Principles and Conservation**.** Cambridge University Press.
3. Caffrey, J.M.; Dutartre, A.; Haury, J.; Murphy, K.M.; Wade, P.M. (Eds.) (2006) Macrophytes in Aquatic Ecosystems: From Biology to Management. Springer.
4. Pandit, A.K. (1998) Freshwater Ecosystems of the Himalaya**.** Taylor & Francis.

BOT-10 CR: ECOLOGY and BOT-20 EA: APPLIED ECOLOGY

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2. Krebs, C.J. 2000. Ecology: The Experimental Analysis of Distribution and Abundance. Benjamin-Cummings
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Bot-11 CR: CELL AND MOLECULAR BIOLOGY; Bot-18 CR: CYTOGENETICS AND GENETICS; BOT-25 CR: GENETIC ENGINEERING OF PLANTS; Bot-30 EA: CROP GENETICS AND MOLECULAR BREEDING

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