21. BOTANY

1. MICROBIOLOGY, MYCOLOGY AND PLANT HEALTH MANAGEMENT
2. PHYCOLOGY AND BRYLOGY
3. PTERIDOPHYTES, GYMNOSPERMS AND ELEMENTARY PALEOBOTANY
4. TAXONOMY OF ANGIOSPERMS AND BIODIVERSITY CONSERVATION
5. PLANT MORPHOLOGY, ANATOMY AND DEVELOPMENTAL BOTANY
6. PLANT RESOURCE UTILIZATION AND ETHNOBOTANY
7. PLANT PHYSIOLOGY
8. ELEMENTRY BIOCHEMISTRY, CYTOLOGY AND MOLECULAR BIOLOGY
9. GENETICS AND PLANT BREEDING
10. ECOLOGICAL PRINCIPLES AND ENVIRONMENTAL BOTANY
11. BIOTECHNOLOGY AND GENETIC ENGEENIRING
12. METHODS IN BIOLOGY

1. MICROBIOLOGY, MYCOLOGY AND PLANT HEALTH MANAGEMENT

A. General concept of microorganisms. Morphology, structure reproduction and life cycle of bacteria and viruses.
B. Culture of microbes, isolation and purification.
C. Role of microbes in root nodules, nif-gene organization, soil, water and air.
D. Industrial microbiology: microbes in production of antibiotics, alcohols, bio-fertilizers, bio-pesticides and dairy products.
E. Structure, reproduction and life cycle in fungi.
F. Classification of fungi with characteristic features of Myxomycotina, Mastigomycotina, Oomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
G. Phylogeny of fungi. Economic importance of fungi.
H. Concept of disease, symptoms of plant diseases, methods of infection.
I. Disease resistance, vertical and horizontal resistance.
J. Genetics of host-parasite interaction.
K. Dissemination of pathogens, methods of disease control.
L. Brief account of structure, disease cycle and control methods of the following:-
1 Damping off 2. Wilt 3. Root rot 4. Stem rot 5. Powdery and Downy mildews 6. Rusts 7. Smuts 8. Leaf spots and leaf blights.
M. Bacterial diseases, viral diseases and mycoplasma diseases: a general account
N. Mycorriza.
O. Economic importance of microbes.

2. PHYCOLOGY AND BRYLOGY

A. Thallus organization, cell structure and reproduction in algae.
B. Algal habitats: a general account.
C. Classificatiion of algae, criteria for classification.
D. Salient features of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.
E. General account of various life cycles in algae.
F. Economic importance of algae.
G. Origin, relationships and evolutionary trends in bryophytes.
H. General account of morphology, structure, reproduction and life history of bryophytes.
I. Classification of bryophytes.
J. Salient features of the following:-
Sphaerocarpales, Marchantiales, Jungermanniales, Metzgeriales, Calobryales, Anthocerotales, Sphagnales, Eubryales, Andreales, Takakiales
K. Economic importance of bryophytes.
L. Bryophytes as monitors of mineral deposition and air pollution indicators.

3. PTERIDOPHYTES, GYMNOSPERMS AND ELEMENTARY PALEOBOTANY

A. A brief account of origin, present and past distribution of pteridophytes.

B. Classification of pteridophytes.
C. Morphology and life history of the following : Psilophytopsida, Psilotopsida, Lycopsida, Sphaenopsida and Pteropsida.
D. Heterospory and seed habit.
E. Evolution of stellar system, telome theory, apogamy and apospory. Economic importance of pteridophytes.
F. Gymnosperms the vessel less and fruit less seed plants.
G. Distribution of Gymnosperms in India.
H. Classification of Gymnosperms.
I. Morphology and life history of the following : Pteridospermales, Bennetitales, Cycadales, Gingkoales, Coniferales, Taxales, Ephedrales, Welwitschiales and Gnetales.
J. A general account of Pentoxylales and Cordaitales.
K. Economic importance of Gymnosperms.
L. Definition of fossils, different types of plant fossils as per their mode of preservation.
M. Methods of study of fossils, reconstruction of fossils with special reference to Indian taxa.
N. Indian Gondwana sequence. Continental Drift hypothesis.

4. TAXONOMY OF ANGIOSPERMS AND BIODIVERSITY CONSERVATION

A. Origin of intrapopulation variation: population and the environment, ecades, ecotypes, evolution and differentiation of species.
B. The species concept, taxonomic hierarchy, principles used in assessing relationships. Delimitation of taxa and attribution of ranks.
C. Salient features of the International Code of Nomenclature.
D. Important systems of classification of Angiosperms (Bentham and Hooker, Hutchinson and Cronquist).
E. Role of anatomy, embryology, cytology, phytochemistry and palynology in taxonomy.
F. Herbaria and Botanical Gardens: a general account.
G. Phytogeography : the concept, plant migration evasion and introduction.
H. Distinguishing features of the following families with their economic importance: Ranunculaceae, Magnoliaceae, Rutaceae, Fabaceae, Rosaceae, Apiaceae, Asteraceae, Primulaceae, Asclepiadaceae, Lamiaceae, Verbenaceae, Convolvulaceae, Acanthaceae, Solanaceae, Amarnthaceae, Euphorbiaceae, Orchidaceae, Cyperaceae and Poaceae.
I. Conservation- the basic concept.
J. Patterns of biodiversity at global and regional levels, α, β and γ diversity, Hotspots, endemism, Environmental Impact Assessment (EIA).
K. Threats to biodiversity- habitat loss, fragmentation, genetic drift, inbreeding, disturbance, pollution, climate change, overexploitation, invasive species and diseases.
L. Conservation of biodiversity- *in situ* and *ex situ* measures.
M. Protected Area Network (PAN) with respect to India.
N. Status of plants based on International Union for Conservation of Nature (IUCN).

5. PLANT MORPHOLOGY, ANATOMY AND DEVELOPMENTAL BOTANY

A. Morphology: Morphology of flower, stamen and carpel, plant adaptations and their morphological nature.
B. Shoot development- organization of the shoot apical meristem (SAM) and differentiation of tissues.
C. Root Development: organization of root apical meristem (RAM).
D. Leaf growth and differentiation.
E. Secondary growth in stem and roots; abnormal secondary growth.
F. Structure of anther, microsporogenesis and development of male gametophyte.
G. Structure of ovule, megasporogenesis, development and organization of embryosacs.
H. Pollination, fertilization , development of endosperm.
I. Development of embryo and seed formation, seed dormancy.
J. Physiology of flowering, senescene and programmed cell death (PCD).

6. PLANT RESOURCE UTILIZATION AND ETHNOBOTANY

A. Plant resources: concept, status, utilization and concerns.
B. World centers of primary and secondary diversities of domesticated plants.
C. Origin, evolution, botany, cultivation, cytotaxonomy and uses of i. cereals and millets ii. Legumes iii. Sugar cane & starch yielding plants and iv. Forage and fodder yielding plants.
D. Fiber yielding plants, medicinal and aromatic plants.
E. Important timber yielding plants and non-timber forest products (NTFPs) such as bamboos, gums, tannins, dyes, resins and beverages.
F. Plants used as ornamentals and avenue trees.
G. Ethnobotany: concept, association with other branches, tools of ethnobotanical studies, world and Indian perspectives.
H. Green revolution: benefits and adverse effects.
I. Intellectual Property Rights: concept, history and protection of IPRs. Patent-requirements, procedures and limitations. International Convention on Biological Diversity (ICBD). Status of IPRs in India regarding plants.
J. Sustainable Development: Basic concept.

7. PLANT PHYSIOLOGY

A. **Plant water relations:** diffusion, osmosis, water potential and its components, plasmolysis, imbibition and absorption of water, root pressure and ascent of sap.
B. **Water loss in plants:** Transpiration and its significance, factors affecting transpiration, mechanism of stomatal opening and closing, guttation.
C. **Translocation in phloem-** Composition of phloem sap, girdling experiment, pressure flow model, phloem loading and unloading.
D. **Mineral Nutrition-** Essential elements, macro and micro nutrients, criteria of essentiality of elements, role of essential elements, mineral deficiency symptoms, transport of ions across cell membrane, active and passive transport, carriers, channels

and pumps, hydroponics and aeroponics.

E. **Photosynthesis** – General concept and historical background, Light harvesting complexes; mechanism of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 and CAM pathways. Photorespiration.

F. **Respiration** – Aerobic and anaerobic respiration, glycolysis, Kerbs cycle(Citric acid cycle) , oxidative phosphorylation, electron transport system, fermentation, R.Q.

G. Nitrogen fixation, nitrogen and sulphur metabolism – Nitrogen fixation, Nitrate and ammonium assimilation; amino acid biosynthesis, sulphate uptake transport and assimilation.

H. Plant Growth Regulators – Physiological effects and mechanism of auxins, gibberellins cytokinins, ethylene, abscissic acid, polyamines, jasmonic acid; hormone receptors and vitamins, brassinoides.

I. Sensory photobiology - Structure, function and mechanism of action of phytochromes, cryptochromes and phototropins;

J. Photoperiodism and Vernalization : Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development vernalization and significance of vernalization

J. **Secondary metabolites** - Biosynthesis of terpenes, phenols, nitrogenous compounds and their role.

K. **Stress physiology** – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

8. ELEMENTRY BIOCHEMISTRY, CYTOLOGY AND MOLECULAR BIOLOGY

A. Structure of atoms, molecules and chemical bonds.

B. Composition, structure, function and metabolism of biomolecules (carbohydrates, lipids, proteins, nucleic acids ,vitamins and pigments).

C. Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction.).

D. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

E. Principles of catalysis, enzymes, classification of enzymes, enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes and coenzymes.

F. Proteins (Ramachandran plot, primary ,secondary and terssary structures.

G. **Membrane structure and function** : Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport,electrical properties of membranes.

H. **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

I. **Organization of chromosomes:** structure of chromosomes, chromatine, heterochromatin, euchromatin, transposons.

J. **Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

K. **DNA replication, repair and recombination:** Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.

L. **Structure of nucleic acids:** Helix (A, B, Z).

M. **Organisation of gene:** Operon, unique and repetitive DNA, interrupted genes, gene families.
N. **RNA synthesis and processing:** Transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNAs, processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport, micro-RNA.
O. **Protein synthesis and processing:** Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins.
P. **Control of gene expression at transcription and translation levels:** Regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing.

9. GENETICS AND PLANT BREEDING

A. **Mendelian principles :** Dominance, segregation, independent assortment. Inheritance and variation.
B. **Concept of gene :** Allele, multiple alleles, pseudoallels.
C. **Extension of Mendelian principles :** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, phenocopy, linkage and crossing over, sex linkage, sex influenced characters.
D. **Gene mapping methods :** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants, construction of molecular maps.
E. **Extra chromosomal inheritance :** Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

F. **Quantitative genetics :** Polygenic inheritance, heritability and its measurements, QTL mapping.
G. **Mutation :** Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis, mutagens.
H. **Structural and numerical alterations of chromosomes :** Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
I. **Recombination :** Homologous and non-homologous recombinations including transposition.
J. Aims, objectives and basic techniques of plant breeding.
K. Crop improvement methods- plant introduction, selection, acclimatization, hybridization, vegetative propagation and grafting.
L. Role of plant breeding- historical aspects and genetic basis. Mode of reproduction in relation to breeding methods, breeding techniques, method of plant breeding in relation to self- pollinated and cross-pollinated plants, clonal selection.
M. Hybridization: Interspecific and inter-generic, pure line, back cross hybridization, self-incompatibility system.
N. Heterosis: Its genetic and physiological basis, economic exploitation of heterosis in maize.
O. Breeding for resistance to diseases, physiological races.
P. Plant breeding work done in India with special reference to wheat, paddy ,potato and

sugarcane.

Q. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.

10. ECOLOGICAL PRINCIPLES AND ENVIRONMENTAL BOTANY

A. **The Environment:** Physical environment, biotic environment; biotic and abiotic interactions.

B. **Habitat and Niche:** Concept of habitat and niche; niche width and overlap; fundamental and realized nichs; resource partitioning; character displacement.

C. **Population Ecology:** Characteristics of a population, population growth curves, population regulation, life history strategies (*r* and *K* selection), concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

D. **Species Interactions:** Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

E. **Community Ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

F. **Ecological Succession:** Types; mechanisms; changes involved in succession; concept of climax.

G. **Ecosystem Ecology:** Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

H. **Applied Ecology:** Environmental pollution (Air, water, soil, noise, electronic and nuclear pollution); global environmental change.

I. **Biodiversity:** status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

J. **Remote Sensing:** Concept and stages in the acquision of remote sensing data, spectral signature, photographic and non photographic sensors, space plate forms, application of remote sensing in ecological and forestry research, Basic principles of photogrammatry and photo interpretation.

K. **Conservation Biology:** Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere Reserves).

11. BIOTECHNOLOGY AND GENETIC ENGEENIRING

A. Introduction to Biotechnology: role in modern life, isolation and culture of different types of microorganisms.

B. Recombinant DNA technology: Tools of genetic engineering, enzymes, plasmids and cosmids, vectors; brief idea of techniques and scope of genetic engineering.

C. Gene cloning: concept and basic steps, application of bacteria and viruses in genetic molecular biology of *E.coli* and bacteriophages in the context of their use in genetic engineering. General characteristics of the cloning vectors used in genetic engineering,

plasmid vectors viz. PER 322, pUC plasmids, M13 vectors, lambda vectors, cosmids, phagemids, artificial chromosomes.

D. Restriction modification, enzymes used in recombinant DNA Technology. endonucleases. ligases and other enzymes useful in gene cloning, PCR for gene/DNA detection, cDNA, use of *Agrobacterium* for genetic engineering in Plants, use of marker genes. Cloning of foreign genes. DNA delivery method, physical and biological methods, Genetic transformation in prokaryotes: transferring DNA into *E.coli.* Chemical intrusion and Electroporation.
E. Plant tissue culture techniques: Plant cell, tissue and organ cultures, tissue culture techniques, collection and storage of germplasm (cryopreservation), application of plant tissue culture with reference to somaclonal variation, embryo culture and embryo resque, anther culture, meristem culture, somatic hybridization and somatic seed production.
F. Industrial biotechnology: Fermentation technology with reference to alcohol production. Microbial fermentation and production of small and macro molecules. Application of immunological principles.
G. Transgenic plants, molecular approaches to diagnosis and strain identification.
H. Genomics and its application to health and agriculture, including gene therapy.
I. Agriculture Biotechnology: Biofertilizers and biological control in fields.
J. Nutritional Biotechnology: Mycotoxins and Health hazards, control of mycotoxin production, single-cell-protein.
K. Elementary idea of the following: Genetically Modified Food Crops, Nano biotechnology , PCR, RTPCR, Gene liberary, Gene Bank. Vectors, general principle of cell signaling, extra cellular signal molecules and their receptors, Southern and Nothern blottings , Nif and Nod Genes,Totipotency, Antibiotics, Mycoprotein, Biosensors .
L. Bioresource and uses of biodiversity.
M. Types of Molecular markers and their role.
N. Bioremediation and phytoremediation.
O. Synthetic seeds and their significance.

12.METHODS IN BIOLOGY

B. **Molecular Biology and Recombinant DNA methods:**

Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods.

Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels.

Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.
Expression of recombinant proteins using bacterial, animal and plant vectors.
Isolation of specific nucleic acid sequences.

Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors.

In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.

Protein sequencing methods, detection of post translation modification of proteins.
DNA sequencing methods, strategies for genome sequencing.
Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.
Isolation, separation and analysis of carbohydrate and lipid molecules.
RFLP, RAPD and AFLP techniques.

B. **Statisitcal Methods:**
Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X^2 test;;

C. Microscopic techniques:
Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes.

D. Methods in field biology:
Methods of estimating population density of plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.