**PET BOTANY SYLLABUS**

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## Section – A

## Research Methodology

**Unit I.:** Introduction of Research:

Meaning of Research, Objectives and types, Research Process, Criteria of good research, defining the research problem.

Research Methodology: Designing, features and concepts of good design, basic principles of experimental design, sampling design- its steps and types, random sampling, measurement and scaling techniques in research.

Method of data collection: primary and secondary data, observation method, interview method, questionnaires, schedules, characteristics of data.

**Unit II: Interpretation and report writing:** meaning, techniques of interpretations, precautions in interpretation, significance of report writing, different steps in report writing, types of report, review writing- review of literature, scientific books and scientific papers.

**Unit III: Basic Methods in Botany: a) Microscopy**: Light Microscopy, Phase contrast Microscopy, SEM & TEM, The flow cytometry and confocal microscopy in karyotype analysis. Ultracentrifugation, TLC, Fractionation, Biochemical analysis, Electrophoresis, PCR, GISH, FISH techniques.

Tissue culture technique, Spectroscopy,

**b) Stains and Staining Procedures:** Preparation and use of various stains used in Botany- Saffranine, Crystle Violet, Light Green, Erythrosine, Acetocarmine, Fuelgen, Basic Fucschin, Cotton Blue, Iodine, Sudan IV, Fluoroglucinol, Carbolic acid etc. Sectioning and Maceration, Microtomy and its staining.

**Unit IV.: Ethical and Legal issues of Research:** Authentication of specimens, Legal permissions for collection of biological material from Local Biodiversity committees, Forest Department, State Biodiversity Board and National Biodiversity Authority.

**Plant Collection and Preservation –**- Plant collection, Voucher specimens, Herbarium techniques, Liquid preservation etc. **Sampling of Plant materials** for Phytochemistry, DNA finger printing, Tissue Culture, Cytological, pathological studies etc.

**Unit V.: Biostatistics:** i) Biostatistics used in analysis of data - mean, variance, standard deviation, standard error, coefficient of variation and 't' test, lay out of field experiments.

**Section B**

- **<u>Unit I :</u> Cell Biology & Molecular Biology, Cytology and Genetics**

## 1. Cell Biology

**A)** **Prokaryotic and eukaryotic Cell:** The ultra-structural details and comparative assessment.

**B)** **i. Plasma membrane:** Molecular organization, current models and functions. Cell wall architecture, biosynthesis, assembly, growth and cell expansion.

**ii Plasmodesmata:** Structure and role in movement of molecules and macromolecules.

**C)** **i. Cytoskeleton:** Organization and role of microtubules and microfilaments. Implications in flagellate and other movements.

**ii**. **Plant vacuole:** Tonoplast membrane, ATPases, transporters, as storage organelle.

**D)** Chloroplast and Mitochondria: Ultrastructure, function and biogenesis. The organization of genome and patterns of gene expression.

**E)** **Nucleus:** Microscopic and submicroscopic organization. Structure and function ofnuclear Envelope. The ultrastructure of nucleolus and its role in rRNA biosynthesis.

**F)** **Ribosomes:** Structure and site of protein synthesis. Mechanism of translation,details of initiation, elongation and termination. The structure and role of RNA.

## 2. Molecular Biology

**A)** **Cell signaling:** Signal transduction, signaling pathways, second messengers, cAMP,genetic disorders ; due to the G protein defect. Lipid derived second messengers.Receptor tyrosine kinase and signaling pathway. Molecular biology of signaling.

**B)** **Other cellular organelles:** Structure and functions of micro bodies, Golgi apparatus, Lysosomes and Endoplasmic reticulum.

**C)** **Proteinsorting:** Targeting of proteins to organelles. Translocation of secretary proteins across the ER membrane. The post translational modifications in RER.

**D)** **Cell Cycle and its molecular aspects:** Control mechanism, the role of cycline and cycline dependent kinases, Retinoblastoma and $E_2F$ proteins. Cytokinesis and cell plate formation. Mechanism of programmed cell death (Apoptosis) and Senescens.

**E) Molecular Cytogenetics**

**i. Nuclear DNA Content:** The C-value paradox, the COT value curve & its significance

**ii**. **Restriction mapping**: Concept and techniques, multigene families and their evolution.

**iii**.Computer assisted chromosome analysis, chromosome micro-dissection and micro cloning.

## 3. Cytology and Genetics

**A) Chromatin organization:**

i. Chromosome structure and packaging of DNA.

ii. Nucleosome organization, DNA Structure (A, B and Z forms)

iii. Organization of centromere and telomere.

iv. Karyotype analysis and the banding patterns.

v. Special types of chromosomes- Polytene, Lampbrush, B-chromosome and sex chromosomes.

vi. Molecular basis of chromosome pairing.

**B) Structural and Numerical alterations in chromosomes:**

i. The origin, meiosis and breeding behaviour of duplication, deficiency, inversion, translocation heterozygotes, haploids, aneuploids and autopolyploids.

ii. The allopolyploids and evolution of major crop plants.

**C) Mutation:**

i. Spontaneous and induced mutations. ii. Physical and chemical mutagens.

iii. Molecular basis of gene mutations. iv. Transposable elements and mutation induced by transposons. v. Site directed mutagenesis.

**D) DNA damage and repair mechanism.**

i. DNA damage and repair mechanism.

ii. Initiation of cancer at cellular level. Proto-oncogenes and oncogenes.

**E) Cytogenetics of aneuploids and structural heterozygotes:**

i. Effect of aneuploids on plant phenotypes.

ii. The use of monosomics and trisomics in chromosome mapping of diploid and polyploid species.

iii. The breeding behavior and genetics of structural heterozygotes.

iv. The complex translocation heterozygotes.

v. Robertsonian translocation.

vi. B-A translocation.

**F) Genetics of prokaryotic and eukaryotic organelles:**

i**. Phage and Bacterial Genetics** —mapping of the bacteriophage genome, genetic recombination in phage, transformation, transduction and conjugation in bacteria

ii.Genetics of mitochondria and chloroplast, cytoplasmic male sterility.

iii. Gene fine structure. Cis-trans test, introns and their significance, RNA splicing.

iv. Regulation of gene expression in prokaryotes and eukaryotes.

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## Unit II: Biology and Diversity of Algae, Fungi and Microbes, Bryophytes, Pteridophytes & Gymnosperms

### 1. Biology and Diversity of Algae, Fungi and microbes

**A) Algae:**

- Introduction of phycology with special reference to Indian work.
- Algae in diversified habitats (Terrestrial, fresh water, marine)
- Criteria used in classification of algae, pigments, reserve food and flagella; and important systems of classification of algae.
- A general account of thallus organization, reproduction and life history of algae.
- Study of important groups of algae with reference to General account, cell structure and method of reproduction in
  - **Cyanophyta -** *Nostoc* and *Oscillatoria.*
  - **Chlorophyta**- salient features of Volvocales, Oedogonials and zygnematales (Desmids)
  - **Xanthophyta -** *Botridiuim, vaucheria.* **Bacillariopyta -** *Diatoms.*
  - **Phaeophyta -** *Ectocarpus*. **Rhodophyta -** *Batrachospermum.*
- Algal blooms, Role of Algae in human welfare, bio fertilizer.

**B) Fungi:**

General Characters, Classification.

- Economic importance of fungi in medicine, Agriculture ( Biopesticide andbiofertilizers), food (SCP. Mushrooms)
- Fungi as plant pathogen – General account of different groups and type study of fungi as pathogen.

- Mastigomycotina - *Phytophora, albugo,* Zygomycotina –*Rhizopus*,
- Ascomycotina – *Claviceps, Erysiphae,* Basidiomycotina – *Puccinia, Ustilago,*
- Deuteromycotina – *Alternaria, Fusarium, Cercospora, Helminthosporium*.

**C) Bacteria:**

General characters, ultrastcture, classification, koch's postulates, archaebacteria and eubacteria.

- Role of agrobacterium in GM crops. Citus canker. Angular leaf spot of cotton.

**D) Phytoplasma:** General Account, ultrastructure and economic importance

- Grassy shoot of sugarcane. Little leaf of brinjal.

**E) Viruses:** General account, ultrasturcture and economic importance of viruses.

- TMV, Papaya leaf curl.

## 2. BIOLOGY & DIVERSITY OF BRYOPHYTES, PTERIDOPHYTES & GYMNOSPERMS

**A) Bryophytes:** Systems of classification, distribution, Economic importance. Habitat, external and internal morphology, reproduction, gametophytes and sporophytes, phylogeny and interrelationships of the orders: Sphaerocarpales, Takakiales, Marchantiales and Jungermanniales, Anthocerotales, Sphagnales, Andreales and Bryales.

**B). Pteridophyta:** Classification, Origin and evolution, Phylogenetic relationship with Bryophyta. Morphology, anatomy, phylogeny and interrelationships of the orders Psilopsida-Psilotales and Psilophytales, Lycopsida- Lycopodiales, Selaginellales, Isoetales, Equisetopsida – Equisetales and Pteropsida- Filicales.

**C)** Sporophyte and gametophyte in Pteridophytes, Stelar organization and evolution, Origin of leaf and Telome concept, Sporocarp, Heterospory and seed habit, Comparison of Pteridophyta with Bryophyta and Gymnosperms.

**D) Gymnosperms:** Introduction, Classification and distribution of Gymnosperms, Morphology, anatomy, reproduction, phylogeny of the orders Pteridospermales (Caytoniaceae, Medullosaceae)

Bennettitales (Williamsoniaceae, Cycadeoideaceae) Cycadales (Cycadaceae) Ginkgoales (Ginkgoaceae) Coniferales (Pinaceae, Araucariaceae) Taxales (Taxaceae) Gnetales (Gnetaceae) and Economic importance of gymnosperms.

**E) Paleobotany:** Introduction, Contributions of Prof. Birbal Sahani, Geological time scale, Fossils and fossilization, Continental drift/ plate tectonics.

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## **Unit III: Taxonomy of Angiosperms, Plant Development & Reproduction, Bioprospecting and Plant Resource Utilization**

### **1. Taxonomy of Angiosperms**

**A)** Angiosperms: Definition, its characteristic features and probable causes of theirevolutionary success. Taxonomy: Definition, scope, principles, aims and objectives oftaxonomy. History of Botanical Explorations in Maharashtra with special reference to Marathwada.

**B)** Phylogeny of Angiosperms: A general account of origin of Angiosperms with reference to timeand place and possible ancestors: euanthial theory (Bennettitales, Caytoniales, Cycadales)and pseudanthial theory (Pentoxylales, Glossopteridae).

**C)** Criteria used for classification; phases of plant classification and brief history on account ofartificial, natural, phylogenetic systems of classifications with special reference to Benthamand Hooker, Cronquist'ssystem, Takhtajan's system and Broad outline of APG III (2009) system of classification and itsmerits and demerits.

**D)** Botanical Nomenclature: Concept of nomenclature, Binomial nomenclature and its advantages, formation of code, Melbourne Code 2011, Principles of International Code of Nomenclature of Algae, Fungi and Plants (ICN), ending of taxa names, Typification.Taxonomic

literature: Flora, manuals, monographs, periodicals, dictionaries, indices, journals, pictorial encyclopedias and books.

**E)** Taxonomic evidences: Morphology, anatomy, embryology, palynology, cytology, phyto-chemistry and numerical taxonomy. Taxonomic tools: Serological and molecular techniques, GIS, GPS, Use of computers in angiosperms taxonomy (Use of computer anddata bases for identification of plants with the help of website). Herbarium Techniques,Major herbaria of the World and India. Contributions of Herbarium BAMU.

**F)** Causes of variations in population; Speciation, Species Concepts; Taxonomic Hierarchy.

**G)** Angiosperm Families: Nymphaeaceae, Hydatellaceae, Magnoliaceae, Papaveraceae, Malvaceae, Sapotaceae, Apiaceae, Asteraceae, Arecaceae and Poaceae.

## 2. Plant Development

**A)** **i. Meristems:** Organization of shoot and root apical meristem, various theories, Cytological and Molecular analysis of SAM, control of tissue differentiation especially Xylem and Phloem.

**ii. Tissue systems:** Differentiation and functions of different tissue systems such as epidermis, parenchyma, chlorenchyma, sclerenchyma, laticifers and glands.

**B)** **i. Vascular tissues:** Origin, structure and functions Xylem and Phloem elements and their taxonomic significance, Wood development in relation to Environment.

**C)** **i. Leaf:** Growth and differentiation, differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll.

**ii. Root:** Initiation and development; lateral roots, root hair, root microbe Interaction.

## 3. Plant Reproduction

**A)** i. **Flower:** Structure and development

ii **Pollination:** Types of pollination, attractions and rewards of pollination, pollination mechanism and vectors, breeding systems, structure of pistil, pollen interaction and fertilization.

**B)** **i. Male gametophyte:** Structure of anthers, micro-sporogenesis, role of tapetum, male sterility, pollen germination, pollen tube growth and development, pollen storage, pollen allergy, pollen embryos.

**ii. Female gametophyte:** Ovule development, magasporogenesis, organization of the embryo sac. Structure of the embryo sac.

**C)** **i. Seed development and fruit growth:** Double fertilization, Endosperm development, Embryogenesis, Ultra-structure and nuclear cytology; Development of dicot and monocot embryos, poly-embryony, apomixes, embryo culture.

## 4. BIOPROSPECTING AND PLANT RESOURCE UTILIZATION

**A)** Bioprospecting: Definition, Introduction, Current practices in Bioprospecting for conservation of Biodiversity and Genetic resources.

Bioprospecting Act: Introduction, Phases of Bioprospecting, Exemption to Act. Fields of Bioprospecting.

**B)** Medicinal Plants Bioprospecting/ Pharmaceutical Bioprospecting: for new drugs, assays in Bioprospecting. Antioxidant assay – NO free radical scavenging assay, Antigenotoxicity assay – MTT assay, Antiviral activities of plants – SRB assay.

**C)** Marine Bioprospecting: Sources of marine planktons and their Bioprospecting, Isolation and cultivation of Marine bioresources, Isolation of Marine Yeast and its industrial applications, Bioactive chemicals from Seaweeds and their applications.

D) Microbial Bioprospecting: Isolation of Microbial metabolites and their bio-activity. Endophytic microbial products as Antibiotics.

**E)** Origin, evolution, botany, cultivation and uses of Food, Fodder, Fibers, Oil yielding crops, wood and timber, Non-wood forest products(NWFPS): Bamboos, Gums, Dyes, Resins, Fruits etc.

**F)** Botany, Chemistry, Properties and uses of Medicinal and Aromatic plants.

**G)** Research Methodology: Separation of secondary metabolites, Pharmacognostic procedures, Authentication of specimens, Preservation of plants and plants products.

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## Unit IV: Plant Physiology and Metabolism & Ecology and Conservation

### 1. Plant Physiology and Metabolism

**A)** **Plant water relations:** Water Potential, Absorption and Transpiration, Stomatal Physiology, Active and passive transport of solutes, Phloem loading and unloading, source-sink relationship, Physiology of plants under water stress.

**B)** **Enzyme:** Nomenclature, Properties and classification of enzymes, Mechanism of Enzyme action, regulation of enzyme action, isoenzymes.

**C)** **Photosynthesis:** Light and dark reactions, pigments and mechanism of light absorption, Photosystem I and II, Emerson enhancement effect, C3, C4 and CAM pathways, significance of C4 and CAM pathways, photorespiration, Photo synthetic productivity.

**D)** **Respiration:** Glycolysis, TCA cycle and its role in synthesis of bio-molecules Mitochondrial electron transport, oxidative phosphorylation, Pentose phosphate pathway, cyanide resistance, Bioenergetics principles.

**E)** **Nitrogen Metabolism:** Nitrification and denitrification, Nitrate assimilation, Biological nitrogen fixation, Biosynthesis of amino acids - reductive animation and trans amination, Protein synthesis, classification of amino acids and proteins, amphoteric nature and zwitter ions, structure of proteins, protein denaturation, Isolation and purification of proteins.

**F)** **Lipid Metabolism:** Fatty acids, lipids, triglycerides, Saponification, oxidation of Fatty acids – alpha and beta oxidation.

**G)** **Plant Growth:** Growth curve, growth analysis, Plant Growth Regulating substance (PGRS), Gibberellins, Cytokinesis, Abscisic acid, Ethylene, role of PGRS in agriculture.

**H)** **Plant Development**: Physiology of flowering, Phytochrome, flowers induction, Seed germination and dormancy, senescence and aging, stress physiology, vernalization and abscission.

## 2. ECOLOGY & CONSERVATION

**A)** i. An introduction to plant ecology and its scope.

ii. **Structure of ecosystem:** Abiotic components (climatic factors, Topographic/factors, Edaphic factors); Biotic components (Interactions among organisms, Autotrophs and Heterotrophs) Ecological Pyramids (Pyramid of numbers, Biomass and energy)

iii. **Functions of ecosystem:** Productivity (Primary and secondary productivity, food chains, Grazing and detritus food chains) food webs. Biogeochemical cycles: C, N, P and S.

**B)** i. **Community ecology:** Classification, Analysis of communities, characteristics of communities, species diversity, Growth form and structure, origin, development and composition.

ii. Competition and coexistence, intra-specific interactions, interspecific interactions, scramble and contest competition model, mutualism and commensalism, prey-predator interactions.

**C)** **Biogeography:** Major biomes of the World -Terrestrial, Tundra, arboreal coniferous forests, temperate and tropical grasslands and deciduous forests, Mediterranean and Desert vegetation, Tropical rain forests; Aquatic Ecosystems- Fresh water, Estuarine and marine. Endemism and hotspots of biodiversity.

**D)** i. Environmental pollution in relation to air, water and soil. Use of fertilizer, pesticides and other chemicals in agriculture and hygiene and their disposal.

ii. Climate change: Greenhouse gases, their sources, trends and role, Ozone layer and its depletion (Global warming, Sea level rise, UV radiation) acid rain, Bioindicator and biomarkers of environmental health.

iii. Concepts of ecological management and sustainable development.

**E)** i. Biodiversity: Concept, types and situation in India. IUCN categories.

ii. Strategies of conservation: *In situ* conservation, protected regions in India: Sanctuaries, National parks, Wetlands, Sacred groves, mangroves for conservation of wild biodiversity. *Ex situ* conservation: Principles and practices, Botanic gardens- Definitions, Criteria and types; Important Botanic Gardens in India and World, BGCI, gene bank, seed banks, cryobanks.

**F)** i. General activities of Botanical Survey of India (BSI) and National Bureau of plant Genetic Resources (NBPGR) for conservation efforts.

ii. Biological Diversity Act 2002; Forest Conservation Act 1980, Wild Life Protection Act 1972 and related international conventions.

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## Unit V: Biotechnology, Genetic Engineering and Bioinformatics

### 1. Biotechnology

**A)** **Biotechnology:** Basic concept, Historical, principles of tissue culture, Cellular totipotency, Discoveries of Plant Growth hormones in brief review, Contribution of Sir Gottlieb Haberlandt, Development of Tissue culture as a technique, Scope and Importance.

**B)** **Introduction to tissue culture:** Tissue culture laboratory, Equipment's in Tissue culture laboratory, Preparation of Media, Media composition, Plant Growth Regulators and their Role, selection of media for specified applications, Selection of explant, Sterilization, Sterilizing agents, initiation of tissue culture

**C)** **Cellular totipotency:** Media for initiation of callus, dynamics of callus growth, measurement of growth, organogenesis and factors controlling it, genome instability in reaction to morphogenesis, somaclonal variation and its applications.

D) **Cell and organ culture:** Plant organ culture; shoot tip, shoot apical meristem, root, leaf, flower and ovary culture, embryo rescue, factors influencing embryogenesis, suspension culture in stationary and stirred tank reactors, isolation of single cells and their culture, measurement of growth,

**E)** **Practical approaches of single cell culture:** Somatic embryogenesis, protoplast isolation, regeneration of protoplasts and protoplasts fusion, Synthetic seeds, generation of cybrid and hybrids, cryopreservation of plant cells.

**F)** **Applications of tissue culture:** Applications in agriculture and Horticulture, Application in Forestry, Application of Tissue culture in pharmaceutical industry. *In situ* and *ex-situ* conservation. *In vitro* mutagenesis and its application. Production of transgenic plants

**G)** **Recombinant DNA technology:** Gene cloning, Vectors, Role of *Agrobacterium*, Gene cloning techniques - Gene gun, Electroporation, Microinjection, Liposome mediated gene transfer, Ultra sonication and Pollen Mediated gene transfer.

## 2. Genetic Engineering and Bioinformatics

**A)** **Genetic Engineering of Plants:** Aims, strategies for development of transgenic. Transformation and regeneration of plants, DNA delivery systems- Agrobacterium tumefaciens, Direct gene transfer. The selection and analysis of transformants. Plant regeneration systems, Stability of the transgenes and Environmental risk assessment. Gene targeting - Transformation of recalcitrant species.

**B)** **Microbial genetic Manipulations:**Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.

**C)** **Introduction to Bioinformatics-** Definition of Bioinformatics- History of Bioinformatics, scope and application of Bioinformatics. Fundamentals of Internet, www, HTML, URLs, Role of internet and www in bioinformatics.

**D)** **Biological Data Acquisition-** The form of biological information; DNA sequencing methods basic DNA sequencing, Types of DNA sequences – genomic DNA, cDNA, Expressed sequence tags (ESTs), Genomic survey sequences (GSSs);

**E)** **Databases: Format and Annotation:** Common sequencing file formats – NBRF/ PIR, FASTA, Files for multiple sequence alignment – multiple sequence format (MSF), ALN format; Files for structural data – PDB format.

**F)** **Bioinformatics Databases:** Primary sequence databases (GenBank-NCBI, the nucleotide

sequence database-EMBL, DNA sequence databank of Japan-DDBJ; Protein sequence and structure databases (PDB, SWISS-PROT and TrEMBL);

Derived (Secondary) Databases of Sequences and Structure: Prosite, PRODOM, PRINTS, Pfam, BLOCK, SSOP, and CATH. Enzyme Database, Biodiversity Database.

**G) Technique's in Bioinformatics- Sequence alignment, database searching and structure prediction:** Pairwise sequence alignment, Database similarity searching, FASTA, and BLAST. Multiple sequence alignment and analysis with CLUSTAL X and CLUSTAL W. Measurement of sequence similarity; Similarity and homology. Phylogenetic tree. Phylogenetic data analysis, tree building methods, tree evaluation & interpretation methods. Phylogenetic analysis with PHYLIP software. Prediction of secondary and tertiary structures with different software's and tools. Structure visualization software's RasMol, SpdbViewer etc.

**H) Introduction to Genomics and Proteomics:** Introduction to genomics- scope and application, Computational genomics, Organization of the prokaryotic and eukaryotic genomes, Human Genome Project. Genome maps and types, current sequencing technologies, partial sequencing, gene identification, gene prediction rules and software, Genome databases; Annotation of genome, Genome diversity: taxonomy and significance of genomes – bacteria, yeast, Homo sapiens, Arabidopsis, etc. Functional Genomics - Microarray - Gene Expression, methods for gene expression analysis; Applications of DNA microarray.