# SARDAR PATEL UNIVERSITY

(A State Government University)

# MANDI (HIMACHAL PRADESH)

## Syllabus for Entrance Test
## of
## Ph.D. Botany
## 2022-23

# 1. Biology and Diversity of Algae and Fungi

## Algae:

1. Algae in diversified habitats (terrestrial, fresh water, marine).
2. Thallus organization in algae.
3. Cell ultra-structure.
4. Reproduction (vegetative, asexual, sexual) and patterns of lifecycle.
5. Criteria for classification of algae (pigments, reserved food, flagella).
6. Fine structure of algal plastids.
7. Algal blooms.
8. Algal biofertilizers.
9. Economic importance of algae.
10. General account of lichens and their economic importance.

## Fungi:

1. Introduction to Mycology: General characteristics, organization of fungal cell, thallus and modifications; cell wall composition; nutrition in fungi (saprophytes, parasites, predators, symbionts); reproduction (vegetative, asexual and sexual), recent trends in the classification of fungi and their significance to human.
2. Structural diversity and mode of reproduction in Dictyosteliomycota (*Dictyostelium*), Myxomycota (*Physarum*), Chytridiomycota (*Synchytrium*), Oomycota (*Saprolegnia*, *Pythium, Phytophthora*), Zygomycota (*Mucor*), Ascomycota (*Taphrina*, *Yeast*, *Neurospora*, *Claviceps*), Basidiomycota (*Ustilago*, *Puccinia*) and Deuteromycota (*Alternaria*, *Cercospora*, *Colletotrichum*, *Pyriciularia*).
3. Sex hormones in fungi, heterothallism and parasexual cycle in fungi,
4. Importance of fungi in different microbiological and biotechnological processes, fungi in food and food industry, in agriculture, and as agents of biotransformation, biodegradation**,** biosorption and biomining.
5. Medical Mycology: General account on pathogenic fungi of human beings. Superficial, cutaneous, sub-cutaneous and systemic mycosis. Opportunistic mycosis - Candidiasis, Aspergillosis and Mucormycosis.

# 2. Cell and Molecular Biology

1. Structural Organization of Plant and Animal Cell:
    i) Cell wall: structure, function and biogenesis.
    ii) Plasma membrane; structure, models, functions, principles of membrane transport; types of carrier proteins and active membrane transport ($Na^+$ and $K^+$ pump, $Ca^{++}$ pump, $H^+$ pump); Ion channels.
    iii) Plasmodesmata: structure, role in movement of molecules, comparison with gap junctions, role and functions of cadherins and selectins.
    iv) Plant vacuole: Tonoplast membrane, ATPases storage organelle.
    v) Structure and functions of micro bodies: Golgi apparatus, lysosomes, endoplasmic reticulum. Transport from ER to Golgi and then to lysosomes; Molecular basis of endocytosis and exocytosis.
2. Chloroplast and mitochondria: Structure, genome organization, gene expression, nucleochloroplastic interactions, biogenesis of mitochondria.
3. Nucleus: structure, nuclear pores, nucleosome organization, nucleolus.
4. The cytoskeleton: Organization and role of microtubules and microfilaments, motor movements implications in flagellar and other movements.
5. Cell cycle and apoptosis: Control mechanisms, role of cyclins, cyclin-dependent kinases, cytokinesis and cell plate formation, mechanisms of programmed cell death and its regulation.
6. Cell signaling through: protein tyrosine kinase receptors, JAK-STAT, cAMP, MAP kinase, NF-kB signaling pathways; insulin and Integrin signaling.
7. Cancer (progenitor cells, oncogenes, tumor suppressor genes) and therapeutic interventions of uncontrolled cell growth.
8. Gene expression:
    i) Structure and types of DNA; replication, DNA damage and repair.
    ii) Transcription, promoters and transcription factors, splicing, mRNA transport, rRNA biosynthesis, differences in prokaryotes and eukaryotes.
    iii) RNA splicing: Nuclear splicing, spliceosome and small nuclear RNAs.
    iv) Translation; structure of ribosome, mechanism of translation initiation, elongation and termination, structure and role of tRNA.
9. Regulation of gene expression in prokaryotes (Run off transcription, Britten-Davidson and Mated models of gene regulation) and eukaryotes.
10. Protein sorting: Targeting of proteins to organelles.

# 3. Biochemistry and Metabolism

**Biomolecules**

Carbohydrates - Monosacharides, disacharides and polysaccharides.

Proteins - Classification and structure, Amino acids classification and general characters.

Lipids - classification and functions of lipids and fatty acids.

Nucleic acids - purines, pyrimidines, nucleotides, structure of DNA and RNA and types of RNA.

Biosynthesis and degradation of purines and pyrimidines.

**Enzymes**

Nomenclature and classification of enzymes, vitamins as co-enzymes**.**

Enzyme Kinetics - Michales –Menten equation. Determination of Vmax and Km, Factors affecting the enzyme activity.

Enzyme inhibition - Competitive and non-competitive.

Mechanism of enzyme action - active sites, Chymotrypsin as a model, Regulation of enzyme activity, allosteric enzymes, PFK, ATC (Phosphofructokinase /Aspartate trans carbamylase)

**Bioenergetics**

Basic Principles of thermodynamics free energy, Enthalpy and Entropy.

Redox Potential and electron transport.

ATP- Production (Chemiosmotic model), high energy phosphates, Coupled reactions.

**Metabolism**

Carbohydrate metabolism - Glycolysis, Krebs cycle, pentose Phosphate pathway.

Glycogenesis, Glycogenolysis, Gluconeogenesis, hexomonophosphate shunt.

Protein metabolism - Transamination and deamination, incorporation of amino acids into TCA cycle, integration between urea cycle and TCA cycle.

Lipid metabolism – fatty acid oxidation and biosynthesis, ketone bodies.

Metabolic defects of carbohydrate and amino acid metabolism.

**Secondary Metabolites**

Biosynthesis and function of secondary metabolites phenolics, flavonoids, terpenoids, alkaloids, steroids.

Importance of Acetyl Co. A and Shikimic acid in intermediary metabolism.

# 4. Tools and Techniques in Biological Sciences

**Instrumentation**

Centrifugation: Principle and applications of Centrifugation; differential and density gradient Centrifugation.

Electrophoresis: Principle, structural components and applications of electrophoresis.

Chromatography: Principle and applications of chromatography; adsorption, Ion exchange, gel permeation and affinity.

Spectrophotometer: Principle, pH meter and applications of Spectrophotometer.

**Microscopy and Histological Techniques**

Microscopy: Principle, and applications of different types of microscopes Light, Phase Contrast, SEM and TEM.

Microtome: Types and applications. Collection and preservation of animal tissue - fixation, embedding, Sectioning, Staining, Identification of deferent components.

Tissue preparation for light microscopy.

Cryotechniques: History and applications of Cryotechniques, cryopreservation of cells, tissue, organisms.

**Cell Culture Techniques**

Cell Culture System and History of development of cell culture.

Culture media preparation and cell harvesting methods.

Commonly used Cell Lines and their Uses.

Design and functioning of tissue culture laboratory.

**Radiolabeling Techniques and Methods in Field Biology**

Detection and measurement of different types of radioisotopes normally used in biology.

Molecular imaging of radioactive material.

Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations

Sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.

# 5. Biology and Diversity of Microbes and Plant Pathogens

**Microbes:**

1. History and scope of microbiology, landmarks in microbiology, major groups of microorganism, characterization, identification and classification of microorganism.
2. Structure of Bacteria: Ultra structure of bacterial cell and cell wall. Nutrition of bacteria: modes of nutrition, nutritional types, growth characteristics, reproduction and genetic recombination: binary fission, resting structure, conjugation, transformation and transduction; mechanism of antibacterial action.
3. Virus: History, structure and classification, plant and animal viruses, nature and transmission, genome organization (TMV, CMV, CAMV and Gemini viruses), isolation and purification, detection, identification and economic importance; bacteriophages, viroids and prions nature and importance, viruses in cancer.
4. Principals of immunology: general account of immunity, allergy, antigen- antibody, serology and types of vaccines.
5. Applications of microbes in agriculture (Biofertilizers, biopesticides), industry (alcoholic beverages, citric acid, penicillin production), environment (pollution indicator and control), and genetic engineering.

**Plant Pathogens:**

1. History of plant pathogens, concept, diagnoses, classification, importance and identification of unknown diseases; symptomology and disease development.
2. Host- pathogen interaction at plant and cellular level: Mechanism of pathogen attack and defense: Physical, physiological, biochemical and molecular aspects.
3. Host pathogen interaction at population level: Transmission and spread of plant pathogens, disease epidemics, modeling and disease forecasting to control crop losses.
4. Management of plant disease: Chemical, Biological, IPM system, development of transgenics, biopesticides and quarantine.
5. Genetics of plant disease: Gene for virulence and avirulence. Their application in resistance and susceptibility, induced resistance (immunization).
6. Specific plant diseases caused by diverse pathogens: Black wart disease of potato, late blight of potato, downy mildew of grapes and bajra, peach leaf curl, powdery mildew of wheat and apple, apple scab, general account of rusts, smut and bunts, fusarial wilt of tomato, rhizome rot of ginger, tikka disease of groundnut, red rot of sugarcane, brown leaf spot and blast of rice. Bacterial blight bean, common scab of potato, fire blight of apple, citrus canker, tobacco mosaic virus.

## 6. Ecology and Environment

1. Ecosystem organization: Life zones, major biomes, concepts of community, ecological succession, structure and functions of ecosystem, primary production, energy dynamics, litter fall, arid decomposition, global biogeochemical cycles, minerals cycles in terrestrial and aquatic ecosystems.
2. Population growth and dynamics: Models of population growth (Stochastic and time lag), reproduction strategies, mating preference, spacing system, r and k selection, case studies in population dynamics.
3. Predation: Predators-Prey interaction, host parasite interaction, role of predation in nature.
4. Competition and mutualism: Types and theories of competition, commensalism and mutualism, plant - pollinator and animal - animal interactions. Niche theory.
5. Biological diversity: Concepts and levels, role of biodiversity in ecosystem functions and stability, speciation and extinction, IUCN, categories of threat, distribution and global patterns, terrestrial biodiversity hotspots.
6. Environmental pollution: Types, sources, effects on plant and animal ecosystems, greenhouse gases, ozone layer and ozone hole, consequences of climatic change.
7. Ecological management: Concepts, sustainable development, sustainability indicators, degraded ecosystem and their regeneration with special reference to waste lands, forests and aquatic ecosystems.

## 7. Cytogenetics and Evolution

1. **Chromosome organization:**
   - i) Structure of chromosomes, DNA packaging and DNA replication
   - ii) Metaphase chromosomes, centromere, kinetochore, telomere and its importance
   - iii) Heterochromatin and euchromatin
   - iv) Chromosome banding
   - v) Polytene and lampbrush chromosomes
2. **Sex chromosomes, sex determination and dosage compensation in *Drosophila* and human**
3. **Mendelian and Non-Mendelian inheritance:**
   - i) Mendelian inheritance and its modification
   - ii) Maternal effect

iii) Epigenetic inheritance

iv) Extra nuclear inheritance

**4. Variation in chromosome structure and number**

**5. Brief description of gene expression:**

i) Genetic code

ii) Transcription and translation

iii) Regulation of gene expression

**6. Gene mutation and DNA repair:**

i) Consequences of mutations

ii) Occurrence and causes of gene mutation

iii) DNA repair

**7. Quantitative genetics:**

i) Quantitative traits

ii) Polygenic inheritance

iii) Heritability

**8. Population genetics and evolution:**

i) Genes in populations

ii) The Hardy-Weinberg Equilibrium

iii) Factors that change allele frequencies in populations.

iv) Origin and evolution of species

v) Biological species concept

vi) Anagenesis and cladogenesis

vii) Allopatric, parapatric and sympatric speciation

viii) Gradualism and punctuated equilibrium

ix) Neo-Darwinism

**9. Molecular evolution**

i) Experimental approaches used to compare species at molecular level

ii) Phylogenetic trees

iii) Molecular drive-a cohesive mode of species evolution

iv) Neutral theory of molecular evolution

## 8. Biostatistics and Bioinformatics

**Introduction to Biostatistics**

Definition and scope

Probability, Discrete and continuous variables, Presentation of Data.

Measures of central tendency: Mean, median, mode

Standard deviation

**Biostatistics Software**

Analysis of variance, Correlation and regression

Sampling: techniques, Errors, Framing Hypothesis, Level of Significance

Hypothesis testing

Student's t test, Chi Square test

**Introduction to Bioinformatics**

Introduction to bioinformatics, genomics and proteomics databases

Nucleic acid sequence database

Genbank, UCSC, ENSEMBL, EMBL, DDBJ, protein sequence databases: Swiss- PROT, PDB, BLAST, BLAST vs FASTA

Bioinformatics and drug discovery

Introduction to computational genomics and proteomics

## 9. Biology and Diversity of Bryophytes and Pteridophytes

**Bryophytes:**

1. General introduction and salient features of Bryophytes. Comparison among Cryptogamous plants.
2. Classification of Bryophytes into Liverworts, Hornworts and Mosses.
3. A general account of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales (emphasis is not to be placed on families or type studies).
4. A general account of Peristome in Mosses.
5. Primitive versus advanced/derived feature and evolutionary lines within Bryophytes.
6. Morphogenesis in Bryophytes.
7. Distribution and ecology of Bryophytes in India with particular reference to Himachal Pradesh.
8. Ecological and economic importance of Bryophytes.

**Pteridophytes:**

1. General introduction and salient features of Pteridophytes, comparison among archegoniatae.
2. Classification of Pteridophytes.
3. A general account of the following fossil Pteridophytes: *Rhynia*, *Horneophyton*, *Asteroxylon*, *Lepidodendron*, *Pleuromeia*, *Sphenophyllum*, *Calamites* and *Osmundites*.
4. Salient feature of Psilopsida, Lycopsida, Sphenopsida and Pteropsida (Emphasis is not to be placed on orders, families or types studies).
5. Structure and evolution of Stelar System in Pteridophytes.
6. Telome theory or the evolution of sporophyte in Pteridophytes.
7. Natural and induced implications of Apogamy and Apospory in Pteridophytes.
8. Heterospory and seed habit in Pteridophytes.
9. Distribution and ecology of the Ferns of the Himalaya with particular reference to Himachal Pradesh.
10. Cytological evolution in Pteridophytes.
11. Economic importance of Pteridophytes.

## 10. Plant Physiology

1. Plant-water relations, transport of solutes: Physicochemical properties of water, water potential, apparent free space, bulk movement of water, SPAC, passive and active solute transport.
2. Stomatal physiology: Chemiosmotic mechanism of stomatal movements, hormonal regulation and significance of calcium ions.
3. Photochemistry and Photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, Photooxidation of water, mechanism of electron and proton transport. Carbon assimilation: The calvin cycle, photorespiration and its significance, $C_4$ cycle, CAM pathways, biosynthesis of starch and sucrose, physiological and ecological considerations.
4. Respiration: Overview of plant respiration, glycolysis, TCA cycle, electron transport and ATP synthesis, structure and functions of ATP, pentose phosphate pathways, glyoxylate cycle, alternative oxidase system.
5. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium

assimilation, sulphate uptake, transport and assimilation.

6. Sensory photobiology: History of discovery of phytochromes and cryptochromes, their photochemical and biochemical properties, photobiology of light-induced responses.
7. Plant growth regulators and elicitors: Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid.
8. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development, role of vernalization.

## 11. Biology and Diversity of Gymnosperms

1. General introduction, classification and salient features of Gymnosperms.
2. Comparison among Tracheophyta.
3. A general account of the following fossils Cycadopsida: *Lyginopteris*, *Crossotheca*, *Medullosa*, *Aulotheca*, *Dolerotheca*, *Calamopitys*, *Glossopteris*, *Caytonia*, *Williamsonia*, *Cycadeoidea*, and *Pentoxylon*.
4. A general account of following fossil Coniferopsida: *Eristophyton*, *Mesoxylon* and *Cordaites*.
5. Salient features of living Cycadales, Coniferales (including *Taxus*) and Ginkgoales (Emphasis is not to be placed on families or type studies.)
6. A general account of Ephedrales, Welwitschiales and Gnetales.
7. Distribution of Conifers in India with particular reference to Himachal Pradesh.
8. Economic importance of Gymnosperms.
9. Structure, properties and uses of the following commercial timbers: Blue Pine, Chir Pine, Deodar, Cypress and Yew.
10. Comparative account of the leaf anatomy of the living Gymnosperms.
11. Comparative study of male cones of living Gymnosperms.
12. Pollination mechanism in living Gymnosperms.
13. Comparative study of female cones of living Gymnosperms.
14. Comparative study of male gametophytes of living Gymnosperms.
15. Comparative study of female gametophytes of living Gymnosperms.
16. Structure and evolution of archegonium in Gymnosperms.
17. Embryogeny in Gymnosperms.

# 12. Plant Biotechnology

**Introduction to Plant Biotechnology**

Define plant biotechnology, various techniques applied in plant biology, scope and application of plant biotechnology.

Plant Tissue Culture a) History and Importance of Plant Tissue Culture; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Culture Media, Nutrients; Protoplast isolation, culture and fusion, Hybridisation of protoplasts. b) Tissue culture applications: Micropropagation, Androgenesis, Virus elimination.

Cryopreservation; Germplasm Conservation, Synthetic Seed preparations.

**Introduction to Genetic Engineering**

Basics of Gene Manipulation, Concepts and scope of genetic engineering, Milestones in Plant Recombinant DNA Technology. Importance of gene manipulation in future perspectives.

Tools in Genetic Engineering: Enzymes in genetic engineering - Restriction endonucleases (History, Types I-IV, biological role, types and action and application. Cloning vectors: Plasmids isolation and purification- Ti Plasmid, pBR322, pUC - series. Phage vectors-M13 phage vectors, Cosmids -Types, Phasmids or Phagemids, Shuttle vectors-types. YAC and BAC vectors, Lambda phage vectors, and Lamda phage DNA as a vectors. Cloning vectors and expression vectors.

**Techniques for plant Transformation**

Integration of plant tissue culture in to plant transformation protocols. Introduction, *Agrobacterium* mediated gene transfer, Ti-plasmid, process of T-DNA transfer and integration, Practical applications of *Agrobacterium*-mediated plant transformation, Transformation in Plants, Direct gene transfer methods.

**Applications of Biotechnology**

GM crops for insect/pathogen resistance/ herbicide tolerance/ Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug).

**Plant Molecular Biology**

Organisation and function of Plant nuclear genome (Arabidopsis thaliana), Genetic transformation of plants by *Agrobacterium*: Genetic organization of Ti plasmids Functions encoded by integrated T- DNA. Molecular mechanism involved in transformation of plants by *Agrobacterium tumefaciens*.

**Crop improvement in terms of yield and quality**

Molecular markers (RFLP, RAPD and DNA finger printing) in crop improvement program. Transgenic plants resistant to insect. Biosafety and bioethics.

## 13. Plant Propagation Techniques

Plant propagation- History, scope and importance. Propagation structures with reference to greenhouse equipment and media. Seed propagation, Germination, type of seed dormancy and breaking, techniques of seed production and handling principles.

Modes of vegetative propagation. Vegetative propagation - advantages and limitations, natural and artificial means. Propagation by specialized vegetative structures- bulbs, tubers corms, rhizomes, runners and suckers. Propagation by cutting and layering- types of cuttings and layering, description of adventitious root and bud formations; processes in layering. Grafting and budding- concept and types, formation of graft union, graft incompatibility, top budding and micro-budding.

Advantage, limitations and applications of vegetative propagation, clones, genetic variation in asexually propagated plants, different methods.

Micropropagation - Techniques and applications in forestry and horticulture. Advantage, limitations and applications of vegetative propagation, clones, genetic variation in asexually propagated plants, different methods.

Seed production in plants. Biology of propagation in plants- General account of sexual and asexual means and their correlation with genetic variability; seedlings versus clonal propagation. Sexual seed - structure, development, ripening and dissemination. Apomixis - phenomenon and implications; concept of asexual seeds and polyembryony. Propagation from seeds - germination process, dormancy- its types and control, methods to break dormancy.

Propagation methods of some selected plants - Apple, Citrus, Grape, Mango, Mulberry, Hibiscus, Rose, Croton, Eucalyptus.

## 14. Biology and Diversity of Angiosperms

**Fossil Angiosperms**

i) General account of fossil Angiosperms

ii) Origin and evolution of Angiosperms (Special reference to Bennettitalean, Gnetalean, Caytonialean and Pentoxylalean theories)

**Taxonomy**

1. **Systems of Angiosperm Classification.**
   i) Phenetic vs Phylogenetic system
   ii) Relative merits and demerits of major systems of classification

iii) APG Classification

**2. International Code of Botanical Nomenclature**

i) History

ii) Principles and rules

iii) Type method

iv) Principle of priority and its limitations

v) Names of Hybrids and cultivars

**3. The Species Concept**

Taxonomic hierarchy: species, genus, family and other categories

**4. Modern taxonomy**

Taxonomy in relation to anatomy, embryology, palynology, cytology, secondary metabolites in plants

**5. Numerical Taxonomy**

i) Concept, characters and attributes

ii) OTU's

iii) Cluster analysis

iv) Cladistics

**Systematics in Practice**

i) Importance and role of herbarium, specimens and their preparation

ii) Botanical Gardens, their importance and role

iii) Value of computers and databases for plants identification

**Concepts of Phytogeography**

i) Endemism, hotspots and hottest hotspots

ii) Plant exploration, invasion and introductions

iii) Local plant diversity and its socio-economic importance

**Plant Resource Conservation**

i) Principles of conservation

ii) Extinctions

iii) Environmental status of plants based on IUCN

iv) Strategies for *In-situ* and *Ex- situ* conservation

**v)** IPR and biopiracy

## 15. Tissue Culture and Horticultural Sciences

### Tissue Culture

i) Methods of tissue culture

ii) Nutrient media used for *in vitro* culture of plant tissues

iii) Cellular totipotency

iv) Haploid induction; fundamental aspects

v) Protoplasts; their isolation, culture and fusion

vi) Applied aspects of tissue culture

a) Clonal propagation

b) Propagation of pathogen-free plants

c) Germplasm storage and conservation

### Horticultural Sciences

1. Nomenclature for cultivated plants
2. Methods of propagation
3. Growth regulators and their use in horticulture
4. *In vitro*-pollination
5. Weed control
6. Principles of landscaping
7. Types of gardens

## 16. Wood Science and Forest Biodiversity

1. Structure of vascular cambium and its role on wood formation.
2. Biochemical components of wood and their distribution in woody cell wall.
3. Basic Structure, formation and modifications of the woody cell wall.
4. Structure, identification and evolution of coniferous woods with particulars reference to Chir Pine, Blue Pine, Deodar, Fir, Spruce, Cypress and Yew.
5. Structure, identification and evolution of dicot woods with particulars reference to Sal, Teak, Shisham, Walnut, Mulberry, Indian Oak, Toon and Himalayan poplar.
6. A general account of texture, figure, spiral grain and knots in woods.
7. Forest Diversity: A general concepts of forest biodiversity, sustainable development and conservation of plant resources, endemism and importance of wild plants.

8. Plant Resources I - Vascular Cryptogams: Economic importance and distribution of vascular cryptogams in the Himalaya with particular reference to Himachal Pradesh.
9. Plant Resource II - Gymnosperms: Economic importance and distribution of Gymnosperms of India with particular reference to Himachal Pradesh.
10. Plant Resource III - Woody Plants (Shrubs, Lianas and Trees): Economic importance of woody plants and their distribution in Himachal Pradesh.
11. Forest Conservation: Factors contributing to the loss of forest biodiversity, IUCN categories of threat and Red Data Book, principles and practices for conservation.

## 17. Anatomy, Palynology and Reproductive Biology of Angiosperms

### Plant Anatomy

i) Plant tissues: General account of different types of tissues (Root, Stem and Leaf)
ii) Apical, lateral and intercalary meristems - their ultrastructure, histochemistry and organogenesis
iii) Secondary growth in general and anomalous secondary growth in stem
iv) Ecological anatomy

### Palynology

i) Basic techniques to study pollen
ii) Pollen viability and storage
iii) Pollen allergy

### Reproductive Biology

1. Male Gametophytes:

   i) Structure of anthers ii) Microsporogenesis ii) Role of tapetum iv) Pollen development v) Male sterility vi) Sperm dimorphism vii) Pollen tube growth and guidance
2. Female Gametophytes:

   i) Ovule development ii) Megasporogenesis iii) Structure and organization of the embryo sac iv) Nutrition of the embryo sac.
3. Pollen-pistil interaction and fertilization:

   Pollen-stigma interaction, sporophytic and gametophytic self-incompatibility (Cytological, biochemical and molecular aspects, *in vitro* fertilization)
4. Seed Development
   i) Endosperm development during early, maturation and desiccation stages.
   ii) Embryogenesis: ultrastructure and nuclear cytology.

iii) Embryo culture

5. Seed Dormancy
   i) Importance and types of Dormancy
   ii) Overcoming seed dormancy

## 18. Plant Resource Utilization and Breeding

1. **Forest Products-Wood and Timber:** General Introduction, formation and composition of wood, difference between softwood and hardwood, Sapwood and Heartwood, storied and non-storied wood, ring-porous and diffuse-porous wood, annual rings, properties and seasoning of wood, uses of wood, structure and identification of important timber plants namely *Pinus*, *Cedrus*, *Tectona* and *Populus*.
2. **Nonwood Forest Products-I:** Bamboo-The Green Gold of India, its structure, properties and uses.
3. **Nonwood Forest Products-II:** Cork **-**Its structure, properties and uses.
4. **Nonwood Forest Products-III:** Tannins and Dyes -A general account.
5. **Nonwood Forest Products-IV:** Gums and Resins - A general account.
6. **Plant Resources-I:** Aromatic plants - a general account, essential oils and perfumery.
7. **Plant Resources-II:** Psychoactive drugs and poisons from plants -a general account.
8. **Plant Resources-III:** Fruits and nuts-a list of important fruits and nuts with particular reference to Himachal Pradesh (Details are not required).
9. **Plant Resources-IV:** Underexploited/underutilized plants-Winged or Goa Bean (*Psophocarpus tetragonolobus*), Jojoba or Hohoba (*Simmondsia chinensis*), Guayule or Wuyule (*Parthenium argentatum*), Subabul (*Leucaena leucocephala*) and Triticale (*Triticosecale*). A general account of edible wild plants.
10. **Plant Resources-V:** Medicinal plants -Some important medicinal plants with reference to Western Himalaya.
11. **Plant Resources-VI:** Bioenergy (Biofuels) of plant origin-A general account of fuel wood, energy plantations, organic waste materials for energy, petroleum plants, alcohol fuel and biogas.
12. A general account of the origin of cultivated plants with special reference to Vavilov's Centres of origin.
13. A general account of plant introduction and acclimatization.
14. Methods and modes of reproduction in relation to breeding in self-pollinated, cross pollinated,

vegetatively propagated and apomictic plants.

15. A general account of inbreeding depression and heterosis, exploitation of hybrid vigour, production of hybrids, composites and synthetics.

## 19. Ethnobotany and Biodiversity Conservation

1. Traditional botanical knowledge
2. History, scope and importance of Ethnobotany
3. Role of Ethnobotany in healthcare and development in cottage industry in India
4. Methods of research in Ethnobotany
5. Sources of information on plant resources of India
6. Global importance of medicinal plant
7. Conservation of plant genetics resources: The role of Biotechnology
8. Biodiversity: Concepts, extent and status of Biodiversity in India, causes of biodiversity loss, sustainable utilization of biological resources
9. Himalayan plant resources
10. Wasteland management in Himalayan region
11. Remote sensing and Bio-resources
12. Bio-indicators
13. Red Data Book

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