ENTRANCE TEST SYLLABUS FOR INTEGRATED Ph.D. PROGRAMME IN BOTANY (2020--2021)

1. PLANT TAXONOMY

Introduction to taxonomy: taxonomy, systematics, classification; role of taxonomy in biodiversity science; taxonomic impediment and global taxonomic initiative
Approaches to plant classification: artificial, natural and evolutionary approaches (historical account); phenetics (principles, selection of characters, character x taxon matrix, similarity matrix, phenogram construction and classification); cladistics (concept, terminology, taxon and character selection, character analysis, cladogram construction and classification)
Taxonomic characters and sources: characters (kinds and criteria); sources (morphology, cytology, palynology, phyto-chemistry, molecular biology)
Taxonomic categories and hierarchy: taxonomic categories (supra-specific, species & infra-specific); taxonomic hierarchy (structure & properties)
Taxonomic tools and institutions: herbarium (collection, preparation and role); botanic garden (concept & importance); taxonomic literature (an overview); Botanical Survey of India (organization & role).
Plant identification: methods of identification; dichotomous keys (kinds and construction); polyclaves (a brief account); cybertaxonomy (concept and scope), e-floras and e-herbaria
Scientific nomenclature: brief 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 **Practice of nomenclature**: type method (concept and kinds); author citation; effective and valid publication; basionyms and synonyms; homonyms; autonyms and tautonyms.

2. MICROBIOLOGY, FUNGI AND PLANT PATHOLOGY

Eubacteria: origin and evolution, diversity assessment and classification criteria; bacterial growth and nutrition, ultrastuctural details; types of reproduction; ecological and economic importance
Archaebacteria: general account, major types (methanogens, extreme halophiles, extreme thermophiles); structural variations (comparison with eubacteria and eukaryotes); evolutionary significance
Cyanobacteria: salient features, cyanobacterial symbiosis, endosymbiotic evolution, biological and ecological importance
Viruses: general characteristics; Origin, chemical nature and ultrastructure.
Replication, tansmission and isolation: mechanisms of viral replication; difference between DNA and RNA viruses; transmission (ways and vectors); isolation and purification of plant viruses
Virus-like agents: virions, viroids and prions - concept, structural aspects and evolutionary importance; economic importance of viruses.
Fungi: general characteristics, cell ultrastructure; unicellular and multicellular organization; cell wall composition; nutrition (saprobic and biotropic); reproduction (vegetative, asexual and

sexual); heterothallism; heterokaryosis, parasexual life cycle; recent trends in classification of fungi

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

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

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

3. ALGAE AND BRYOPHYTA

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

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

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.

Origin of Bryophytes- evolution of gametophyte and sporophyte; economic, ecological and microbial importance of bryophytes, symbiotic associations of bryophytes

Liverwort and Hornworts: classification, morphology, anatomy and reproduction of Marchantiales, Metageniales, Jungermanniales and Anthocerotales.

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

4. PTERIDOPHYTA AND GYMNOSPERMS

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

Fossil pteridophytes: structural features and evolutionary significance of Psilophytales Lepidodendrales, Calamitales

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

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

Fossil gymnosperms: structural features and evolutionary significance of Pteridospermales, Cycadeoidales, Cordiatales

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

5. ECOLOGY

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.
Habitat and niche: concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
Species interactions: types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
Community ecology: nature of communities; community structure and attributes; species diversity and its measurement, richness and evenness; edges and ecotones; guilds
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.
Community stability: diversity- disturbance, and diversity stability relationships; ecology of plant invasion- process of invasion.
Ecosystem organization: biotic component-food chains, food web, trophic cascades; abiotic component-soil formation, soil profile development, soil horizons and soil classification.
Ecosystem function: primary production (gross and net primary production, controlling factors and methods of measurement), energy flow pathways, ecological efficiencies; litter accumulation and decomposition (mechanisms, substrate quality and climatic factors).
Global bio-geochemical cycles: biogeochemical cycles of C, N, P and S (pathways, processes, budgets and anthropogenic impact)
Diversity Patterns: species abundance distribution, diversity patterns (latitudinal gradient-contributory factors and explanatory theories)
Biogeography: MacArthur and Wilson's island biogeography equilibrium theorylimitations and modifications; colonization vs. extinction; species area relationship
Biomes: types (terrestrial and aquatic), distribution and unique features

6. CELL AND MOLECULAR BIOLOGY

Cell wall and plasma membrane: structure and functions; membrane proteins – integral and transmembrane proteins.
The cytoskeleton: organization and role of microtubules and microfilaments, motor proteins.
Nucleus: nuclear membrane and nuclear pore complex, transport of proteins and RNAs across nuclear membrane.
Chloroplasts and Mitochondria: genome organization, protein import, endo-symbiotic origin.
Golgi complex and ER: role in protein sorting and transport, Lysosomes – endocytosis and phagocytosis.
The cell cycle: phases of cell cycle, regulation of cell cycle progression, role of cyclin and cyclin-dependent kinases.
DNA: DNA structure, mechanism of DNA replication, DNA damage and repair mechanisms.
Transcription: RNA polymerase, introns and their significance, transcription factors, mechanism of transcription, major differences between prokaryotes and eukaryotes (at transcriptional level).

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

7. REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY OF ANGIOSPERMS

Flower development: floral evocation, floral organ formation, flowering in perennials, seasonal flowering, polycarpy and biennial bearing.
Male and female gametophyte: structure of anther, role of tapetum, micro-sporogenesis 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.
Pollination, pollen-pistil interactions and fertilization: pollination mechanisms, pollination syndromes, structure of pistil, pollen germination and compatible pollenstigma interactions, sporophytic and gametophytic self-incompatibility, pollen tube growth and guidance, double fertilization
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.
Root development: organization of root apical meristem (RAM); vascular tissue differentiation; lateral roots, root hairs.
Leaf growth and differentiation: determination; phyllotaxy; control of leaf form; differentiation of epidermis with special reference to stomata**,** trichomes, and mesophyll
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
Patterns in plant development: growth, differentiation and development, genetic control and hormonal regulation of development, physiology of hormones in plant development.
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
Wood development in relation to environmental factors.

8. CYTOGENETICS AND GENETICS

Chromosomes: chromosome structure and chromatin organization,
Nuclear DNA content and c-Value paradox, repetitive DNA - types and utility.
Molecular organization of centromere and telomere; euchromatin and heterochromatin,
Chromosome banding techniques (Q, C and G) and their utility.
Concept of split genes, overlapping genes and pseudo genes.
Karyotype – concept, essential features and evolution of karyotype;
B chromosomes – origin, characteristics and distribution of B- chromosomes
Structural changes: types of structural changes in chromosomes-deletion, duplication,inversion and translocation, origin and meiotic behaviour of structural heterozygotes

Robertsonian translocation, B-A translocation.
Euploidy: origin, meiosis and breeding behaviour of haploidy, autopolyploids and allopolyploids.
Chromosome and chromatid segregation in autopolyploids
Role of polyploidy in crop improvement and evolution of crop plants.
Aneuploidy: types of aneuploids, origin, meiosis and breeding behaviour of aneuploids, aneuploid aberrations in humans.
Mutations- spontaneous and induced mutations, types of point mutations, molecular basis of gene mutations, concept of pleiotrophy, back mutations and suppressor mutations
Alien addition and substitution line: concept, development and utility
Population genetics: Hardy-Weinberg equilibrium and factors affecting allelic frequencies
Flow cytometry (concept and utility).

9. PLANT METABOLISM

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

10. PLANT PHYSIOLOGY

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.
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 ensorregulator system in bacteria and plants); sugar-sensing and signaling in plants (hexose, sucrose and trehalose signaling).

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.
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.
The control of flowering: floral evocation (internal and external cues), endogenous clock and its regulation; photoperiodic control of flowering; vernalization and its significance.

11. PLANT TISSUE CULTURE AND GENETIC ENGINEERING

Introduction: historical perspective and scope
Cellular totipotency: concept, cytodifferentiation and its mechanism
Cell culture and cell cloning: isolation of single cells from plant organs and cultured tissues; cell suspension culture, culture of single cells; organogenesis-processes and controlling factors, shoot- bud differentiation and somatic embryogenesis
Haploids: androgenic and gynogenic; ontogeny of androgenic haploids, applications of haploids in plant breeding.
Somatic hybridization: isolation, culture and fusion of protoplasts; selection, regeneration and utility of hybrids and cybrids.
Industrial applications: production of secondary metabolites and their applications, hairy root cultures and bioreactors
Germplasm conservation: cryopreservation of plant cells and organs, short term and long term storage.
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.
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.
DNA sequencing: Maxam-Gilbert's chemical degredation and Sanger's chain termination method, molecular markers (RAPD, AFLP, SSR & SNP) – concept and utility.
Genetic engineering of plants: Agrobacterium the natural genetic engineer, Ti plasmids, mechanism of gene transfer, applications of transgenic plants.
Direct methods of gene transfer (electroporation and biolistics), biosafety – possible ecological risks and ethical concerns of GM crops.
Genomics and proteomics: concept and applications, microarray technology and its applications. Brief account of gene silencing; antisense RNA technology and RNA interference (RNAi).

12. PLANT RESOURCE UTILIZATION

Plant biodiversity: concept, utilization and concerns
Ethnobotany and archaeo-ethnobotany: concept, scope, and role in tracing origin and evolution of domesticated plants.

Origin of agriculture: time and place of origin, archaeological and other evidences
World centres of origin and domestication of cultivated plants: Vavilov's and de Candolle's concept, centres and non-centres, secondary centres, plant introduction
Green revolution: concept, concerns, benefits and adverse consequences.
Origin, evolution, domestication and uses of: food plants **(**maize and buckhwheat), fodder **(**alfalfa), fibre plants **(**cotton**),** Spices **(s**affron), legumes **(**sources of food), oil yielding plants **(m**ustard and groundnut)
Beverages: origin, evolution, domestication and processing of tea and coffee
Sugars and starch: origin, evolution, domestication, extraction and utilization of cane sugar and beet sugar; general account of starch yielding plants.
Rubber: origin, distribution, production, extraction, processing and utilization of rubber.
Paper making: sources of raw material and processing of paper
Agricultural innovation for meeting food demands: agricultural bio-technology, synthetic crops, agriculture in arid zones.
Psychoactive drugs: sources, chemistry of action, use and misuse of *Papaver somniferum* and *Cannabis sativa*