

M.Sc. Botany
(Applicable to students admitted in 2009 onwards)
(w.e.f. examination of 2009 onwards)

M.Sc. I (Previous)

Semester I

Paper I	- Microbiology: Plant Virology and Bacteriology	100 Marks
Paper II	- Fungi and Plant Pathology	100 Marks
Paper III	- Algae, Lichens and Culture Techniques	100 Marks
Paper IV	- Bryophytes	100 Marks
Practical	- Based on Papers I to IV	200 Marks
		Total 600 Marks

Semester II

Paper V	- Pteridophytes	100 Marks
Paper VI	- Gymnosperms and Palaeobotany	100 Marks
Paper VII	- Angiosperm - Plant Development and Reproduction	100 Marks
Paper VIII	- Project (Review/Literature survey based on Papers I to VII (Semesters I & II)	100 Marks
Practical	- Based on Papers V to VII (including viva-voce on project & field excursion)	200 Marks
		Total 600 Marks

M.Sc. II (Final)

Semester III

Paper I	- Angiosperms: Taxonomy and Economic Botany	100 Marks
Paper II	- Environment, Ecology and Plant Soil Relationship	100 Marks
Paper III	- Cytology, Genetics and Cytogenetics	100 Marks
Paper IV	- Plant Breeding and Biostatistics	100 Marks
Practical	- Based on Papers I to IV	200 Marks
		Total 600 Marks

Semester IV

Paper V	- Plant Physiology	100 Marks
Paper VI	- Cell Biology and Plant Biochemistry	100 Marks
Paper VII	- Biotechnology and Analytical Techniques	100 Marks
Paper VIII	- Project (Review/Literature survey based on Papers I to VII (Semesters III & IV)	100 Marks
Practical	- Based on Papers V and VII (including viva-voce on project & field excursion)	200 Marks
		Total 600 Marks

Microbiology: Plant Virology and Bacteriology

Unit-I: Plant virus classification, structure, transmission, detection

- * Nomenclature and classification of plant viruses
- * Range of plant virus particle and genomic organization
- * Morphological, anatomical, and biochemical changes in virus infected plants.
- * Molecular aspects of plant virus transmission
- * Purifications and electron microscopy of viruses
- * Virus detection by serological and nucleic acid hybridization methods

Unit-II: Plant virus replication, sub-viral pathogens, techniques, disease, control.

- * Infection and replication of plant viruses
- * Gene expression strategies in plant viruses.
- * Molecular mechanism of plant resistance to virus infection and modern methods of plant virus disease control.
- * Disease caused by plant viruses-
 - Sunhemp rosette on sunnhemp (Tobamovirus)
 - Papaya ringspot on papaya (Potyvirus)
 - Leaf curl of tobacco (Geminivirus)
 - Distortion mosaic on *Tabernaemontana* (Ilarvirus)
 - Tungro on paddy (Tungro virus complex)
- * Structure, replication and pathogenicity of viroids
- * Structure and replication of viruses infecting bacteria

Unit-III: Bacteria- History, classification, structure and genetics

- * History of microbiology.
- * Classification of bacteria and archaea based on Bergey's Manual of Systematic Bacteriology
- * Bacterial cell structure, function of cell components
- * Bacterial genome structure, replication, expression and recombination, and plasmids

Unit-IV: Bacterial metabolism, Soil microbiology, disease, applications

- * Bacterial nutrition and metabolism, including Nitrogen fixation
- * Antibiotics and their mode of action.
- * Introduction to recombinant DNA technology
- * Biotechnology applications of microbiology
- * Diseases-
 - Brown rot of potato/brinjal (*Pseudomonas solanacearum*)
 - Soft rot of carrot/onion- *Erwinia cartovora*.
 - Little leaf of Brinjal (*Phytoplasma* sp.)

Practicals: Based on syllabus above

Fungi and Plant Pathology*Unit-I***General aspects of structure, reproduction, systematics and phylogeny.**

Historical account, thallus organization and cell structure.

Nutritional types of fungi: biotrophs, hemibiotrophs, symbionts and necrotrophs.

Reproduction, hormonal mechanism of sexual reproduction, parasexuality, life cycles.

Fungal systematics, phylogeny, fossil fungi.

Fungal biotechnology.

*Unit-II***Comparative study of fungal groups**

Comparative study of the following main groups of fungi:

Myxomycota:

- (i) Myxomycetes- *Stemonitis, Arcyria*.
- (ii) Plasmodiophormycetes- *Plasmodiophora*

Eumycota:

- (i) Mastigomycotina
Chytridiomycetes- *Synchytrium, Allomyces, Monoblepharis*.
Oomycetes- *Saprolegnia, Achlya, Pythium, Phytophthora, Sclerospora, Peronospora*.
- (ii) Zygomycotina- *Zygorhynchus, Pilobolus, Choanophora, Entomophthora*.
- (iii) Ascomycotina- *Yeasts, Taphrina, Protomyces, Emericella, Penicillium, Erysiphe, Phyllactinia, Chaetomium, Sordaria, Claviceps, Xylaria, Daldinia, Nectria, Phyllachora, Morchella, Capnodium*.
- (iv) Basidiomycotina- *Auricularia, Puccinia, Gymnosporangia, Phragmidium, Uromyces, Ravenalia, Melampsora, Tolyposporium, Ustilago, Sphacelotheca, Tilletia, Urocystis, Graphiola, Clavaria, Lycoperdon, Geaster, Cyathus*.
- (v) Deuteromycotina- *Colletotrichum, Helminthosporium, Alternaria, Cercospora, Rhizoctonia*.

*Unit-III***Principles of phytopathology**

Historical development and present status of phytopathology.

Classification of plant diseases, general symptoms and diagnosis.

Concept of disease, Koch's postulates, specialization of parasitism, pathogenesis, role of enzymes and toxins in pathogenesis.

Genetics of host- pathogen interaction.

Defense mechanism in host, effect of infection on host physiology.

Dissemination of phytopathogens, plant disease forecasting and management.

Mycotoxins and storage diseases.

Application of biotechnology in plant pathology.

Unit-IV

Plant diseases caused by fungi, nematodes, abiotic factors and their control

Epidemiology, symptoms, etiology, perennation and control of following diseases:

Fungal diseases:

Green ear disease of bajra- *Sclerospora graminicola*

Damping off of seedling and fruit rot- *Pythium*

Stem gall of coriander- *Protomyces macrosporus*

Peach leaf curl- *Taphrina deformans*

Ergot of rye- *Claviceps purpurea*

Rust of gram- *Uromyces ciceris – aurientinii*.

Rust of linseed- *Melampsora lini*.

Rust of wheat- *Puccinia recondite*, *P. striiformis*

Covered smut of barley- *Ustilago hordei*

Loose smut of oats- *Ustilago avenae*

Loose smut of bajra- *Tallyposporium penicillariae*

Red rot of sugarcane- *Colletotrichum falcatum*

Leaf spot and shot holes- *Alternaria spp.*

Tikka disease of groundnut- *Cercospora spp.*

Foot rot of gladioli- *Fusarium spp.*

Diseases caused by nematodes:

(i) Ear cockle of wheat- *Anguina tritici*

(ii) Root knot of vegetables- *Meloidogyne incognita*, *M. javanica*, *M. arenaria*

Abiotic/Non pathogenic diseases:

(i) Black tip of mango

(ii) Black heart of potato

Algae:*Unit – I*

General characters and definition, study of important systems of classifications, criteria used in algal classifications including recent trends. Range of thallus structure and organization. Pigmentation. Nature of reserved food products, chief cell organelles. Reproductive diversity, life history patterns and alternation of generations, origin, evolution, inter-relationships, applied phycological studies specially in relation to Soil fertility (biofertilizers), Productivities in fresh and marine waters, Symbiotic algae, role of algae in water pollution, algal blooms, fossil algae, cyanophages.

Unit-II

A systematic study of thallus organization, reproduction, phylogeny and inter-relationships of the principal classes of algae with the help of the under mentioned types.

Cyanophyceae :

Chroococcales - *Microcystis*

Nostocales - *Oscillatoria, Lyngbya, Nostoc, Anabaena, Gloeotrichia, Scytonema*

Stigonematales – *Stigonema*

Prochlorophyceae – *Prochloron***Chlorophyceae :**

Volvocales – *Chlamydomonas, Gonium, Pandorina, Eudorina, Volvox*

Chlorococcales – *Chlorococcum, Chlorella, Oocystis, Pediastrum, Hydrodictyon, Scenedesmus.*

Ulotrichales – *Uronema, Schizomeris, Microspora, Enteromorpha, Ulva, Prasiola, Sphaeroplea.*

Cladophorales – *Cladophora, Pithophora, Rhizoclonium*

Chaetophorales – *Chaetophora, Stigeoclonium, Fritschiella, Draparnaldiopsis, Trentepohlia*

Oedogoniales – *Odeogonium, Bulbochaete, Oedocladium*

Conjugales – *Zygnema, Mougeotia, Sirogonium, Cosmarium, Closterium*

Slphonales – *Protosiphon, Bryopsis, Caulterpa, Codium, Valonia*

Charales – *Chara*

Xanthophyceae :

Heterosiphonales – *Botrydium, Vaucheria*

Bacillariophyceae :

Pennales – *Navicula*

Centrales – *Melosira*

*Unit-III***Phaeophyceae :**

Ectocarpales – *Ectocarpus, Pylaiella*

Sphacelariales – *Sphacelaria*

Dictyotales – *Dictyota, Padina*

Cutleriales – *Cutleria*

Laminariales – *Laminaria*

Fucales – *Fucus, Sargassum*

Rhodophyceae :

Nemolionales – *Batrachospermum*
Gelidiales – *Gelidium*
Cryptonemiales – *Corallina*
Gigartinales – *Gracilaria*
Rhodomeniales – *Champia*
Ceraminales – *Polysiphonia*

Unit-IV

Lichens

A general account of Lichens and its symbionts, thallus structure, reproduction, physiology, classification and distribution, Chemistry of Lichens, Isolation of symbionts and synthesis of thallus, Economic importance

Study types :

Dermatocarpon, Cladonia, Parmelia, Usnea, Heterodermia.

Microscopy:

Compound (Bright and Dark field), Phase contrast, Fluorescence, Ultra violet and Infra Red, Stereoscopic, Scanning and Transmission Electron Microscopy.

Culture Techniques

Culture methods pertaining to various lower groups (Algae, Fungi, Bacteria, Bryophytes)

Bryophytes:*Unit-I*

General characteristics, life cycle and broad outline classification of bryophytes.

Ecology, Physiology and Reproductive biology of Bryophytes.

Endemism and endemic liverwort genera of India.

Bryophytes as indicator of mineral enrichment and environmental pollution.

Spore- diversity, development, dispersal and germination.

Moss protonema, protonemal differentiation and bud induction.

*Unit-II***MUSCI:**

Characteristic features, criteria of classification, range of gametophytic and sporophytic organization (morphology, anatomy and their distribution in India) in various orders/families of the classes:

Sphagnales	-	<i>Sphagnum</i>
Andreaeales	-	<i>Andreaea</i>
Takakiales	-	<i>Takakia</i>
Buxbaumiales	-	<i>Buxbaumia</i>
Bryales	-	<i>Physcomitrium, Fontinalis, Splachnum</i>
Polytrichales	-	<i>Polytrichum</i>

*Unit- III***HEPATICAE:**

Characteristic features, criteria of classification, range of gametophytic and sporophytic organization (morphology, anatomy and their distribution in India) in various orders/families of the classes:

Calobryales	-	<i>Calobryum, Haplomitrium</i>
Metzgeriales	-	<i>Pallavicinia, Riccardia, Metzgeria</i>
Jungermanniales	-	<i>Jungermannia, Porella, Ptychanthus, Radula</i>
Sphaerocarpaceae	-	<i>Riella, Sphaerocarpaceae</i>
Monocleales	-	<i>Monoclea</i>
Marchantiales	-	<i>Reboulia, Plagiochasma, Asterella, Lunularia, Dumortiera, Targionia, Cyathodium</i>

*Unit: IV***ANTHOCEROTAE:**

Characteristic features, criteria of classification, range of gametophytic and sporophytic organization (morphology, anatomy and their distribution in India) in various orders/families of the classes:

Anthocerotaceae	-	<i>Anthoceros, Folioceros</i>
Notothylaceae	-	<i>Notothylas</i>
Dendrocerotaceae	-	<i>Dendroceros, Megaceros</i>

Origin, evolution, fossil history, phylogeny of principal classes: Hepaticae, Musci, and Anthocerotae.

Pteridophytes

Unit-I: Past and present distribution of ferns, Ecology of Pteridophytes, Origin and evolution, Cytology in relation to taxonomy; Evolution of stellar system Evolution of sorus, Heterospory and seed habit, Telome theory, Apogamy, Apospory and Alternation of generation.

Unit- II : Classification, morphology, life history, present and past distribution and phylogeny of the following:

Rhyniopsida - *Rhynia, Horneophyton, Cooksonia, Hicklingia, Eogaspesia, Taeniocrada, Hedeia, Yarravia, Hostimella, Nothia, Trimerophyton and Dawsonites*

Psilotopsida - *Psilotum and Tmesipteris*

Lycopsida:

Asteroxylales - *Asteroxylons, Zosterophyllum and Baragwanthia*
 Lycopodiales - *Lycopodium and Phylloglossum*
 Protolpidodendrales - *Protolpidodendron and Cepodexylon*
 Selaginellaes - *Selaginella*
 Lepidodendrales - *Lepidodendron, Sigillaria, Bothrodendron and Lipidophloion*
 Isoetales - *Isoetes, Stylites, Pleuromeia and Nat-barstiana*

Equisetopsida:

Hyeniales - *Hyenia*
 Pseudoborniales - *Pseudobornia*
 Sphenophyllales - *Sphenophyllum and Cheirostrobus*
 Calamitales - *Calamites, Asterocalamites, Annularia, Asterophyllites, Calamostachyus, Pallaeostachya and Calamocarpon*
 Equisetales - *Equisetum*

Unit-III: Primofilices:

Protopteridales - *Protopteridium, Aneurophyton and Rhacophyton*
 Zygopteridales - *Zygopteris, Amkyropteris, Botryopteris and Strautopteris*
 Cladolyales - *Cladoxylon, Pseudosporochus and Calamophyton*

Filicopsida**Eusporangiatae:**

Ophioglossales - *Ophiolossom, Botrychium and helminthostachys*
 Marattiales - *Marattia, Angiopteris, Marattiopsis and Psaronium*

Protolptosporangiatae:

Osmundales - *Osmunda, Todea, Thamnopteris, Osmundites and Cladophelbis*

Unit-IV:**Leptosporangiatae:**

Schizaeales - *Anemia, Schizaea, Lygodium*
 Pteridales - *Pteris, Adiantum, Ceratopteris and Actinopteris*
 Dicksoniales - *Dicksonia, Pteridium Lindsaea, Dennstaedtia*
 Davalliales - *Davallia, Nephrolepis*
 Hymenophyllales - *Hymenophyllum, Trichomanes*
 Gleicheniales - *Gleichenia, Geschenites, Stromatopteris*
 Matoniales - *Matonia, matonidium*
 Cyatheales - *Cyathea, Alsophila*
 Aspidiales - *Asplenium, Athyrium, Dryopteris, Tectaria*
 Blechnales - *Blechnum*
 Polypodiales - *Dipteris, Polypodium*
 Marsileales - *Marsilea, Regnellidium, Pilularia*
 Salviniales - *Salvinia, Azolla*

Gymnosperms and Palaeobotany*Unit-I*

Evolutionary tendencies in Gymnosperms. Origin, relationship and economic importance of Gymnosperms, Embryology of Gymnosperms and its relevance to Forest Genetics, Silviculture and Taxonomy

Classification past and present, distribution of Gymnosperms with special reference to India. A study of their morphology, structure, life history, interrelationship and phylogeny of the following:

*Unit- II***Cycadopsida**

- Pteridospermales - A general account, affinities and interrelationship of the different families and members of the order
- Lyginopteridaceae - *Lyginopteris, Heterangium, Rhetinangium, Sphenopteris, Kaloxylon, Rachriopteris, Lagenostoma, Sphaerostoma, Genomosperma, Physostoma, Telangium, Crosstheca*
- Medullosaceae - *Medullosa, Sutcliffa, Myiloxylon, Neuropteris, Althopteris, Trigonocarpus, Stophanospermum, Codonotheca, Whittlesseya, Aulacotheca, Dolerotheca, Potonia*
- Glossopteridaceae - *Glossopteris, Gangamopteris, Palaeovittaria, Rhabdotacenia, Vertabraria, Scutum, Hirsutum, Lanceolatus, Ottokaria, Cistella, Plums, Lidgettonia*
- Peltaspermaceae - *Lepidopteris, Pellaspermum, Antevsia*
- Corystospermaceae - *Dicroidium, Xylopteris, Umkomasia, Spermatocodon, Pilophorsperma, Pteruchus*
- Caytoniaceae - *Sagenopteris, Caytonia, Caytonanthus*
- Cycadales - A general account of living and fossil *Cycadales*, their geographical distribution along with its significance and evolutionary tendencies and cytogenetics, cultural studies as well as economic importance.
- Nilssonioles - *Nilssonia, Ctenis, Pseudoctenis, Baenia, Androstrobus*

Cycadeoideales

- Bennettitales - A general account of the order with affinities and interrelationship of the following:
- Williamsoniaceae - *Williamsonia, Ptilophyllum, Pterophyllum, Otozamites, Dictyozamites, Bennetticarpus, Weltrichia.*
- Wielandiellaceae - *Wielandiella, Anomzamites, Williamsoniella, Nilssoniopteris* along with their fructification.
- Cycadeoideaceae - *Cycadeoidea* (Bennittites)
- Pentoxylales - A general account of Pentoxylales *Pentoxylon, Nipaniophyllum, Carnoconites, Sahinia.*

Unit-III

Coniferopsida

- Cordaitales - A general account of the order with its different families and genera
- Eristophylaceae - *Eristophyton, Endoxylon, Bilignea*
- Cordaitaceae - *Cordaites, Noeggerathiopsis, Mesoxylon, Dadoxylon, Metacordaites, Perapitys, Artisia, Amyelon, Cordaitanthus, Cardiocarpus*
- Poroxylaceae - *Poroxylon, Rhabdospermum*

Ginkgoales

- Trichopityaceae - *Trichopitys*
- Ginkgoaceae - *Ginkgo, Baiera, Sphenobaiera, Ginkgoites, Arctobaiera, Windwardia, Ertophyllum*
- Coniferales - The past and present distribution of conifers with special reference to origin and distribution of coniferous flora of India. Evolutionary trends in conifers. The morphology and evolution of megastrobilus and cone-scale complex.
- Lebachiaceae - *Lebachia, Ernestiodendron, Walahia, Walchoistrobus, Carpentieria, Buriadia*
- Voltziaceae - *Pseudovoltzia, Voltziopsis, Ullmania*
- Palissyaceae - *Pallisya, Stachyotaxus*
- Pinaceae - *Pinus, Cedrus, Abies, Pseudotsuga, Picea, Larix*
- Araucariaceae - *Araucaria, Agathis, Wolemia*
- Taxodiaceae - *Taxodium, Cryptomeria, Sequoia, Sequoiadendron, Metasequoia, Sciadopitys*
- Cupressaceae - *Cupressus, Thuja, Juniperus*
- Podocarpaceae - *Podocarpus, Saxegothaea, Phyllocladus, Dacrydium, Microcachrys, Acrophyle*
- Taxales - *Palaeotaxus, Taxus, Austrotaxus, Pseudotaxus, Torreya, Amentotaxus*

Unit-IV

Gnetopsida

- Ephedrales - *Ephedra*
- Gnetales - *Gnetum*
- Welwitschiales - *Welwitschia*

PALAEOBOTANY

Plant fossils, their methods of preservation, investigation and their importance in Stratigraphy and economic geology.

A study of the standard stratigraphic scale and the succession of representative floras in the various geological epochs and their bearing on plant morphology and evolution.

SEMESTER-II: Paper VII
Angiosperms: Plant Development and Reproduction

M.M. 100

Unit- I

Development of Root:

Organization of RAM, cell fates, Differentiations of vascular tissue, Formation of aerial roots, root hairs

Development of shoot:

Cytological analysis of Sam, Growth and differentiation of shoot

Tissue differentiation especially Cambium, Xylem and Phloem

Formation of secretory ducts, Laticifers

Wood structure and development

Leaf growth and differentiation, Venation and differentiation of mesophyll

Determination of phyllotaxy

Differentiation of epidermis with special reference to cuticle, stomata and trichomes.

Unit- II

General Morphology and reproductive parts

Floral meristem

Formation of floral organs, floral Development

Genetics of floral organ differentiation, origin of Epigyny

Homeotic mutants in Arabidopsis and Antirrhinum

Evolution of Angiosperm flower

Unit- III

Microsporogenesis, Tapetum, Microgametogenesis

Pollen -Pistil interaction, Pollination mechanism and its control, Male sterility

Megasporogenesis, Structure of ovule, organization of embryosac, gene function during mrgagametogenesis

Sexual incompatibility, Barriers to fertilization, Pollentube structure and growth, Methods of overcoming incompatibility

Double Fertilization, Development of Endosperm- its types and Haustoria

Embryogenesis

Polyembryony, Apomixis- causes, classification and applications

Unit-IV

Structure and growth of fruit and seed

Experimental and applied embryology

Morphogenetic Phenomenon- Symmetry, Polarity, Correlation

Differentiation and Totipotency

Angiosperms: Taxonomy, Economic Botany and Morphology***Unit-I***

Principles of systematics, Phenetic *versus* Phylogenetic system: Relative merits and demerits of major systems of classification viz. Benthan & Hooker, Engler & Prantl, Hutchionson, and Cronquist, Dahlgren and Thorne
ICBN (History, Principles and Applications)
Relevance of Taxonomy, Species Concept: Various models
Phytogeography with special reference to discontinuous areas, endemism, Hotspots and hottest Hotspots

Unit- II

Taxonomy as a synthetic discipline, Modern tools of taxonomy: Morphology, Anatomy, Cytology, Photochemistry, embryology, Palynology, Ultra structure, Genome Analysis, Nucleic Acid Hybridization and GIS; Evolution of Angiosperms.

Unit-III

Comparative study of interrelationship in dicots and monocots, Interesting taxonomic features and phylogeny of the following Dicot and Monocot families:

Dicots: Ranunculaceae, Caryophyllaceae, Tiliaceae, Malvaceae, Cucurbitaceae, Brassicaceae, Capparaceae, Rosaceae, Apiaceae, Amaranathaceae, Euphorbiaceae, Mimosaceae, Caesalpiniaceae, Fabaceae, Asclepiadaceae, Rubiaceae, Asteraceae, Acanthaceae, Scrophulariaceae, Polygonaceae.

Monocots: Cyperaceae, Poaceae, Lilaceae, Orchidaceae, Arecaceae, Commelinaceae, Zingiberaceae.

Unit-IV

Origin, Cultivation and improvement of major crops viz. Wheat, Rice, Maize, Pearl Millet and sorghum
General account of pulses along with their economic uses
Sugars, Starches (Sugarcane, Potato, Sweet Potato)
Fibres: Extraction and utility of cotton, Jute, coir and Paper making fibres
Morphological identification of Pharmacognostic/anatomic characterization of major woods fats, oils, medicinal plants, petrocrops and beverages (at least 10 examples of each class of product be given)

SEMESTER-III: Paper II
Environment, Ecology and plant-soil relationship

M.M. 100

Unit-I

Environmental Botany: Environmental pollution, the problems and its causes and prevention, indicator plants (pollution of air, water and soil, radioactivity and noise)
Modern Environmental problems- Acid rain, Ozone depletion and Green house effect

Unit-II

Plant ecology, Plant responses to environmental factors (climate, edaphic, Biotic, topographic and geographic factors.

Ecosystems- The concept, ecosystem component and major ecosystem of the world.
Ecosystem functioning. Community dynamics-successional changes.

Unit-III

Study of plant communities (quantitative and qualitative), characteristics of communities, methods of study and classification of plant communities.

Population dynamics, principles of population regulation.

Phytogeography: Vegetational zone, Important forest types of India. Interpretative phytogeography: Principles and concepts of plant distribution.

Unit-IV

Soil: Soil and natural medium for plant growth. Origin of soil, Minerals as a source of plant nutrients. Soil forming process and its impact on soil profile development. Properties of soils, ion exchange, calcareousness, salinity, sodicity. Organic matter, Soil fertility: Concept, basic methods of fertility evaluation and maintenance. Soil types of India.

SEMESTER-III: Paper III
Cytology, Genetics and Cytogenetics

M.M. 100

Unit-I

Genome –Basic concept and organization

- Chromosome structure, nucleosome, solenoid and packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, karyotype analysis, banding patterns, karyotype evolution, specialized chromosomes—polytene chromosomes, lampbrush chromosomes, B chromosomes
- Nuclear DNA content, C-value paradox, multigene families and their evolution, Structure and Properties of Nucleic acids: Structure, Chemical, Physical, Spectroscopic and thermal properties of nucleic acids. Dissociation and reassociation kinetics of DNA, Cot curves, Cot $\frac{1}{2}$ values and its significance. Unique, moderately repetitive and highly repetitive DNA, conformation of nucleic acids. (A, B, Z DNA, t-RNA, micro RNA) , DNA sequencing and amplification, molecular genetic maps, genome projects
- In situ hybridization to locate transcripts in cells—FISH, GISH, Computer assisted chromosome analysis, chromosome microdissection and microcloning, flow cytometry and confocal microscopy in karyotype analysis
- Genetic Fine Structure, cis-trans test, Fine structure analysis in eukaryotes
- Allele concept, multiple alleles, isoalleles, pseudoalleles

Unit-II

Inheritance Genetics

- Principles of Mendelian inheritance and Interaction of genes: Introduction to pre Mendelian, Mendelian and Post Mendelian genetics. Complementary, epistasis, inhibitory, Duplicate, Polymeric, Lethal and additive interaction of genes.
- Cytoplasmic inheritance: - Cytoplasmic inheritance involving chloroplast (*Mirabilis jalapa*, *Zea mays*) and Mitochondria (petite yeasts and cytoplasmic male sterility in higher plants), mitochondrial and chloroplast genomes, interaction between nuclear and cytoplasmic genes. (Rubisco and Cytochrome oxidase)
- Quantitative Inheritance: Qualitative and Quantitative traits, Continuous variation, Inheritance of quantitative traits, (corolla length in *Nicotiana*, cob length in *Zea mays*), multiple factors hypothesis and heritability.
- Population genetics: -Gene and genotype frequencies, Hardy-Weinberg law, Factors affecting Hardy-Weinberg equilibrium (selection, mutation, migration and genetic drift)

Unit-III

Cytogenetics and induced variation

- Structural changes in chromosomes: Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Cytological

- consequences of crossing over in Inversion and translocation heterozygotes
Genetics of structural heterozygotes, complex translocation heterozygotes, Robertsonian translocations, B-A translocations
- Numerical alterations in chromosomes: Origin, occurrence and meiosis of haploids, aneuploids and euploids. Origin and production of autopolyploids, chromosome and chromatid separation, allopolyploids. Induction and characterization of trisomics and monosomics. Transmission of trisomics and monosomics.
 - Recombination and Linkage: - Concept of Linkage, Types and Applications, Concept and Types of Recombination, Molecular mechanism of recombination, site specific recombination estimation of recombination percentages and map distances, Gene mapping in Fungi using ordered and unordered tetrads of Neurospora Three point test crosses and estimation of linkage distances in plants. Gene maps and physical maps.
 - Mutation—Spontaneous and induced mutation, physical and chemical mutagens, molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, site directed mutagenesis, DNA damage and repair mechanism- Types of DNA damage, enzymes involved in repair of DNA, excision repair, recombination repair and mismatch repair systems.

Unit- IV

Molecular Genetics

- Cell Cycle and apoptosis: Control mechanisms, role of cyclins and cyclin dependent kinases, mechanism of programmed cell death
- Genetic Code
- Gene Structure: Organization and Structure of prokaryotic and eukaryotic genes; structure and role of promoters, exons, introns, terminators and enhancers.
- DNA Replication: - Mechanism of prokaryotic and eukaryotic DNA replication, replication apparatus, Origins of replication, priming and DNA polymerases.
- Transcription: RNA polymerases and their role, Transcription apparatus, Transcription in prokaryotes and eukaryotes, Initiation, elongation and termination, RNA processing, reverse transcription and cDNA synthesis, Ribonucleoproteins, Structure of mRNA.
- Regulation of Transcription in prokaryotes and eukaryotes: Operon concept (Lac, Tryptophan, Arabinose) positive and negative regulation of prokaryotic genes, eukaryotic transcription factors. transcriptional and translational control

PLANT BREEDING AND BIOSTATISTICS

Unit-I

Plant Genetic resources and reproductive systems

- Plant Genetic resources: Genetic diversity in plants, Penetrance and Expressivity, Pleiotropy, Centres of origin, Importance of genetic diversity in crop improvement and its erosion, Collection and evaluation of germplasm, Concepts of crop conservation and regulation. *in situ* and *ex situ* conservation
- Competition in natural populations, Inter genotype competition, Environmental variation
- Heritability-definition and types, Estimates of heritability
- Reproductive systems and Pollination control mechanisms: Sexual reproduction (Cross and self pollination), asexual reproduction, Apomixis, identification of apomictic plants, Genetics of Apomixis
- Incompatibility and Male sterility: Genetic, physiological and biochemical basis of incompatibility, Utility of self incompatibility, Evolution of incompatibility mechanism; Genetic and Cytoplasmic male sterility

Unit-II

Hybrid breeding

- Hybridization and its role, Principles of combination breeding and its application.
- Hybrid breeding in self and cross-pollinated crops. Development of hybrids, Use of male sterility in development of hybrids,
- Testing of combining ability, prediction of performance of hybrids- single cross hybrid, three way cross hybrid, double cross hybrid, Multiple crosses –composite cross breeding,
- Back cross method of breeding-theory of transfer of alleles
- Protoplast fusion
- Heterosis, Theories of heterosis, Environmental heterosis, Inbreeding depression
- Methods of direct gene transfer, QTL Analysis and Marker assisted selection

Unit-III

Breeding methods and their contributions

- Breeding methods in self fertilizing species –Pedigree method, bulk method, single seed descent, dihaploidy, Genotype assessment, recurrent selection , reciprocal recurrent selection
- Breeding methods in cross fertilizing species-Mass selection, family selection, combined selection, inter population selection schemes
- Factors affecting efficiency of breeding methods
- Breeding methods of important crop plants e.g. wheat, rice
- Role of mutation in Plant Breeding, generation of variability using mutagens and isolation of useful mutants and their achievements
- Role of polyploids in crop improvement , Biometrical genetics of autotetraploids and their achievements

Unit- IV

Biostatistical methods

- Importance and scope of Biostatistics
- Statistical terms and symbols
- Sample and sampling, Collection and representation of data-tabulation, graphical, diagrammatic
- Measures of Central tendency
- Measures of dispersion: range, mean deviation, Standard deviation, Variance, Deviation
- Correlation and regression
- Tests of significance: Significance and difference in means, Standard error of mean, Standard error of SD, Students 't' test
- Chi-square test
- Correlation and regression - Meaning, kinds of correlation, coefficient of correlation, methods of studying correlation. Aims of regression analysis. Kinds of regression analysis.

Plant Physiology***Unit-I***

Water metabolism: Cell osmotic quantities-osmosis, osmotic potential, water potential
Mechanism of water uptake and translocation- water absorption by roots, root pressure and turgor pressure. Phloem loading and unloading
Transpiration and its regulation: Stomatal opening and closing.
Photosynthesis: general aspects and historical background. Action spectra, organization of photosynthesis apparatus, pigments and light harvesting complexes.
Photolysis of water, Mechanism of electron transport- structure and functions of components of Photosystem I and II. Role of peoxiredoxins. Photophosphorylation, Protom transport and ATP synthesis in chloroplast- ATP synthetase.
Carbon assimilation: Calvin cycle and its regulation, RUBISCO, Photorespiration (C₂ Cycle) and C₄ cycle and their regulation. CAM pathway, Photosynthetic responses to light, CO₂ and Temperature. Synthesis of Starch and Sucrose.

Unit- II

Respiration: Aerobic and anaerobic respiration. Glycolysis, Kreb's Cycle and their regulation. Substrate level Phosphorylation. Alternate Glycolytic reaction (Gluconeogenesis). Pentose phosphate Pathway. Glyoxylate cycle.
Electron Transport System and ATP synthesis- NADPH DH in plant mitochondria, F₁-F₀ ATPase, Alternate oxidase system. Chlororespiration.
Lipid Metabolism: Synthesis of fatty acids (saturated and unsaturated) and lipids (phospholipids). Fatty acid degradation- α , β and ω oxidation.

Unit-III

Mineral Nutrition: Essential and Beneficial elements. Role and deficiency effects of essential nutrient elements.
Stress Physiology: Plant responses to abiotic stress. Stress Proteins (HSP, LEA). Water deficit and drought, heat, chilling and freezing, salinity, light and anoxia stress. Oxidative stress- reactive oxygen and nitrogen species, antioxidative defense system.
Sulphur metabolism: Sulphate uptake and its assimilation.

Unit- IV

Flowering: Floral evocation, Florigen concept, circadian rhythms,. Photoperiodism and its regulation. Vernalization. Phytochrome and its functions.
Apical dominance, abscission, dormancy (bud and seed), seed germination and Senescence. Plant movements.
Nitrogen metabolism: Biological nitrogen fixation-free living and symbiotic organisms, nitrogenase enzyme complex, nodule formation and nod factors.
Mechanism of nitrate reduction-nitrate and nitrite reductase. Ammonia assimilation.

Unit-I

Cell structure and function:

Structural organization of cell, the cytoskeleton, organization of microtubules and microfilaments, plasmodesmata.

Cell organelles (microbodies, Golgi apparatus, Lysosomes, endoplasmic reticulum, vacuole, ribosomes, nucleus, chloroplast, mitochondria).

Plant membranes and membrane transport.

Cell wall, Plasma membrane and their structural models and functions.

Active and Passive uptake of ions- facilitated diffusion, primary and secondary active transport, ion carriers, channel proteins and pumps (Na^+/K^+ and Ca^{2+} pumps). Membrane transport proteins- Plasma membrane H^+ - ATPase, vacuolar H^+ -ATPase and H^+ pyrophosphatases.

Unit –II

Plant growth regulators:

Structure, function, synthesis, cellular and molecular mechanism of action of auxins. Gibberellins, Cytokinins, Ethylene, Abscisic acid, brassinosteroids, Polyamines, Jasmonic acid and salicylic acid.

Unit-III

Macromolecules:

Structures and functions of carbohydrates, Amino acids, Proteins, Lipids and Nucleic acid.

Secondary metabolites and their function:

Cutins, Suberins, Lignin, Anthocyanins, Chalcones, Isoflavones, Stilbenes, terpenes, Sterols. Nitrogen containing compounds- alkaloids, Cyanogenic glycosides, Glucosinolates, Non- protein amino acids.

Biosynthesis of phenylalanine, tyrosine and tryptophan (Shikimic acid pathway), terpenes (acetate mevalonate pathway) and phenylpropanoids (acetate malonate pathway).

Unit- IV

Enzymes:

General aspects, classification, mode of action, allosteric mechanism, regulation, Active sites, reversible and irreversible enzyme inhibition. Enzyme kinetics and Michaelis- Menton equation.

Signal transduction:

Overview, role of membranes, receptors and G- proteins, Ca-calmodulin, phospholipid signaling, cyclic nucleotides- adenylyl cyclase. Protein kinases- receptor like protein kinase (RLKs), mitogen activated protein kinase (MPAK), cyclin dependent protein kinase (CDK). Protein phosphatase, Auxin, GA and ABA signal transduction.

BIOTECHNOLOGY and ANALYTICAL TECHNIQUES***Unit-I***

Plant cell and tissue culture

- Plant Cell and Tissue culture: Introduction, history, scope, concept of cellular differentiation, totipotency
- Culture media and laboratory requirements
- Micropropagation-Organogenesis and embryogenesis, Bioreactors, Embryo rescue, Endosperm, nucellus culture
- Somaclonal variation---applications and reasons for generation
- Somatic hybridization –protoplast culture, regeneration and somatic hybridization, cybrids
- Production and uses of haploids
- Applications of plant tissue culture

Unit-II

Genetic Engineering

- Cloning vectors (plasmid and bacteriophage vectors, cosmids BAC and YACs. and Enzymes (restriction endonucleases, polymerases, reverse transcriptase, alkaline phosphatase, polynucleotide kinase, Ligases, terminal transferases)
- DNA cloning, preparation of plasmid DNA, Restriction and electrophoresis, ligation, transformation and analysis of recombinants.
- Methods of direct and indirect gene transfer in plants, *Agrobacterium*, Ti and Ri plasmids, application of genetic engineering, transgenic plants for pest and disease resistance, abiotic stress tolerance, production of useful products.
- Principles and methods of Genetic Engineering, Gene libraries and cDNA libraries, Polymerase chain reaction, DNA fingerprinting, DNA Synthesis, DNA Sequencing, Southern blotting, RAPD, RFLP, Restriction mapping.
- Introduction to Genomics, Proteomics and Bioinformatics.

Unit-III

Biotechnology and Human welfare

- Applications of genetically engineered bacteria in crop production and protection, biodegradation of xenobiotics and toxic wastes, production of chemicals and fuels
- Biopesticides and integrated pest management, Biofertilizers, Organic farming
- Biotechnology in pollution control and phytoremediation
- Restoration of degraded land –Development of stress tolerant plants, microbes for improving soil fertility
- Intellectual Property rights and Protection—brief introduction
- Patenting of Biological material and its implications
- Ethics in biotechnological research

Unit- IV

Instrumentation and analytical techniques:

- Microscopy: - Simple, Compound, Phase contrast, Fluorescence, Electron (SEM and TEM) microscopy, Micrometry
- Centrifugation: - Rotors, Bench top, Low speed, High speed, Cooling ,Ultracentrifuge. Electrophoresis: - Native, Denaturing, Isoelectric focusing, 2 D Electrophoresis.
- Spectroscopy: - UV, Visible, IR, Raman, Spectrofluometry, Mass, AAS, NMR,
- ESR Radioactivity: - GM counting, Scintillation counting, Autoradiography.
- Chromatography: - Paper, TLC, Column, Gel Filtration, Affinity, Ion Exchange,
- HPLC, GC.
- Microtomy
- DNA Chip technology and Microarrays
- Mass Spectrometry for genome and proteome analysis
- Biosensors
- Bioinformatics-history, data mining, limitations