West Bengal State University

Berunanpukuria, Malikapur, Barasat,

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Syllabus for the M.Sc. in Botany (w. e. f. 2014-16 session)

Program Specific Output: The discipline of Botany has through the past decades transformed itself rapidly through interdisciplinary and technological inputs which has brought about a paradigm shift in our knowledge and understanding the diversity of plant and microbe life as well as their interaction. This choice oriented MSc. program in Botany endeavours to incorporate these new developments into the syllabus to keep the student abreast of the developments and to prepare him/her for pursuing a career either in the academia or in the industry. These concepts and skills are developed from both the core and elective courses (Special papers), many of which include current relevant topics taught from review papers, students' projects, and in part by the research programs undertaken by the department.

The MSc. program also endeavours to link current research findings and developments in the field and allied areas with the subject specializations in a holistic way. The USP of the program is to prepare and expose the student to translational research as far as applicable for the various streams in Botany if not fully through the practical syllabus then at least through the theoretical syllabus.

Course outline

For Theory

- 14 weeks a Semester; 1 credit = 14 lectures; 1 lecture = 1 hr class; Total theory teaching hours each day = 3 hrs = 3 lectures; 15 lectures a week; 210 lectures per Semester

For Practical

- 1 credit = 28 one-hr classes; 224 classes per semester required; thus for practical 15 weeks per semester is required

Credit distribution for each Semester

Semester	Theory	Practical	Total
I	15	08	**23**
II	12	06	**18**
III	15	08	**23**
IV	09	08	**17**

THEORY
PART-I (Semester I &II)

SEMESTER-I		
Course No.	**Course Title**	**Credit**
221 101	**Integrated Life Sciences (ILS)**	3
221 102	**Phycology**	3
221 103	**Bryology**	3
221 104	**Mycology & Lichenology**	3
221 105	**Plant Virology & Bacteriology**	3
221 106	**Laboratory Course**	8
Total credit		**23**
SEMESTER-II		
221 201	**Plant Systematics**	**3**
221 202	**Plant Ecology and Environmental Biology**	**3**
221 203	**Pteridophytes, Gymnosperms, Palaeobotany & Palynology**	**3**
221 204	**Plant Pathology & Crop protection**	**3**
221 205	**Laboratory Course**	**6**
Total credit		**18**
PART-II (Semester III & IV)		
SEMESTER-III		
221 301	**Molecular & Cellular Genetics**	**4**
221 302	**Plant Breeding**	**4**
221 303	**Plant Physiology & Biochemistry**	**4**
221 304	**Plant Developmental Biology & Anatomy**	**3**
221 305	**Laboratory Course**	**8**
Total credit		**23**
SEMESTER-IV		
221 401 a, 221 401 b	**Plant Virology & Molecular Mycology and Molecular Plant Pathology**	**9**
221 402 a, 221 402 b	**Molecular Genetics & Advanced Cell Biology and Applied Plant Breeding & Plant Tissue Culture**	**9**
221 403 a, 221 403 b	**Advanced Plant Physiology & Biochemistry and Plant Molecular Biology**	**9**
221 405	**Practical, Dissertation Project work and Seminar**	**8**

Total credit		**17**

PRACTICALS		
SEMESTER-I		
Course No.	**Course Title**	**Credit**
221 106	**Integrated Life Sciences (ILS)**	00
221 106	**Phycology**	2.0
221 106	**Bryology**	2.0
221 106	**Mycology & Lichenology**	2.0
221 106	**Plant Virology & Bacteriology**	2.0
Total credit		**8.0**
SEMESTER-II		
221 205	**Plant Systematics**	1.5
221 205	**Plant Ecology and Environmental Biology**	1.0
221 205	**Pteridophytes, Gymnosperms, Palaeobotany & Palynology**	2.0
221 205	**Plant Pathology & Crop protection**	1.5
Total credit		**6.0**
SEMESTER-III		
221 305	**Molecular & Cellular Genetics**	2.0
221 305	**Plant Breeding**	2.0
221 305	**Plant Physiology & Biochemistry**	2.0
221 305	**Plant Developmental Biology & Anatomy**	2.0
Total credit		**8.0**
SEMESTER-IV		
221 405	**Plant Virology & Molecular Mycology and Molecular Plant Pathology**	9
221 405	**Molecular Genetics & Advanced Cell Biology and Applied Plant Breeding & Plant Tissue Culture**	9
221 405	**Advanced Plant Physiology & Biochemistry**	9

	and Plant Molecular Biology	
221 405	**Dissertation Project Work and Seminar**	8
Total credit		**17**

Marks allotment

Semester	Course title	Mid Semester	End Semester	Total marks
I	Integrated Life Sciences (ILS)	**10**	**30**	**40**
	Phycology	**10**	**25**	**35**
	Bryology	**10**	**25**	**35**
	Mycology & Lichenology	**10**	**30**	**40**
	Plant Virology & Bacteriology	**15**	**35**	**50**
	Laboratory Course			**100**
				300
II	Plant Systematics	**15**	**35**	**50**
	Plant Ecology and Environmental Biology	**15**	**35**	**50**
	Pteridophytes, Gymnosperms, Palaeobotany &Palynology	**15**	**35**	**50**
	Plant Pathology & Crop Protection	**15**	**35**	**50**
	Laboratory Course			**100**
				300
III	Molecular & Cellular Genetics	**15**	**35**	**50**
	Plant Breeding	**15**	**35**	**50**
	Plant Physiology & Biochemistry	**15**	**35**	**50**
	Plant Developmental Biology & Anatomy	**15**	**35**	**50**
	Laboratory Course			**100**
				300
IV	Plant Virology & Molecular Mycology and Molecular Plant Pathology	**25**	**50**	**75**
		25	**50**	**75**
	Molecular Genetics & Advanced Cell Biology and Applied Plant Breeding & Plant Tissue Culture	**25**	**50**	**75**
		25	**50**	**75**
	Advanced Plant Physiology & Biochemistry and Plant Molecular Biology	**25**	**50**	**75**
		25	**50**	**75**
	Practical	**Continuous evaluation =50** **Final Practical Examination Viva=25**		**75**
	Seminar and Dissertation Project Work	**25**	**50**	**75**
				300
Grand Total				**1200**

BOTANY COURSES (THEORY)

SEMESTER-I

221 101: INTEGRATED LIFE SCIENCES (ILS) (40 marks)

Course outcome: This integrated life science course will familiarize the students with very basic aspects of life sciences as a whole. It will introduce the students to basic common arenas of life sciences such as basic cell structure, function, cell signaling, cancer biology, immunology, development, molecular biological techniques, Mendelian genetics and basic biostatistics. It is a very preliminary course and augments the students' vision and acceptance for more complex courses based on this foundation. This course will greatly assist the students following other harder courses in the later part of semesters.

Course details:

- Structure of atoms, molecules and chemical bonds, Composition, structure and function of bimolecules, Stabilizing interactions, Principles of biophysical chemistry
- *Membrane structure and function:* Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
- *Cellular communication:* Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.
- *Cancer:* Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.
- *Immunology:* Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. Structure and function of antibody. MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells. Autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immune deficiencies, vaccines.
- Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

- Morphogenesis and organogenesis in Eukaryotes: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick. Organogenesis and regeneration of different organs in vertebrates. Differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.
- Methods in Biology**:** Molecular biology and recombinant DNA methods: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; regeneration of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods, strategies for genome sequencing,
- Histochemical and immunotechniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.
- Brief description of Plant and Animal cell culture and cryopreservation technique for artificial seeds.
- Laws of inheritance: Mendel's Laws, concepts of dominance, segregation, independent assortment, deviation from Mendelian inheritance.
- Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, phenocopy.
- Basic statistics- Populations and sample, Experimental design, Data analysis, graphs, average, measure of central tendency, dispersal, probability, co-efficient distributions (Chi-square, Binomial, Poisson, and Normal), Tests of significance- t-test, z-test, F-test, U-test and others, Regression and correlation, Analysis of variance, Errors.

221 102: Phycology (35 marks)

Course outcome: Completion of the course will familiarize the student with diversity of the major life form of algae. Their biology, genetic structure, phylogeny, interrelationships, role in environment as well as their commercial uses and industrial applications.

Course details:

- **Diversity & distribution of algae**: Brief account of distribution of algae in India. Thallus organisation, cell structure and reproduction in various groups. *Chalamydomonas reinhardtii* (genomic model) and *Porphyra* as experimental systems.

- **Classification** Molecular taxonomy- recent developments in algal classification, special emphasis on emerging trends in molecular phylogeny and inter relationship of principal groups of algae.
- **Algal Biotechnology**: Historical perspectives, aquaculture (micro and macro algae cultivation), bioremediation, recent developments and future of algal biotechnology; Algal bio-fuels-algal biodiesel, bio-ethanol and biological hydrogen production; algae in global warming- carbon capture by algae.
- **Industrial Phycology**: Products, processes and applications, sea weeds polysaccharides like agar, Carrageenan and alginates. Bioactive compounds from algae: bio fertilizers; algae in bioengineering, photo- bioreactors and raceway ponds.

221 103: Bryology (35 marks)

Course outcome: Completion of the course will familiarize the student with diversity of the major life forms of bryophytes. Their biology, genetic structure, phylogeny, interrelationships, role in environment as well as their commercial uses and industrial applications.

Course details:

- Modern classification of Bryophytes (Shaw and Goffinet) with general characters up to order level.
- Origin and Evolution of Bryophytes.
- Bryophyte association with microorganism fungi and animals. Poikilohydry, Desiccation tolerance.
- Breeding system, population ecology and population genetics of bryophytes.
- Anisopory and sexual dimorphism.
- Cytogenetics of bryophytes. Expression of genes under stress conditions.
- Hormonal regulation of gametophyte development in bryophytes.
- Role of bryophytes in ecosystem dynamics and in the global carbon budget.
- Bryophyte chemistry and its taxonomic implications. Biologically active compounds in bryophytes.
- Bryogeography and conservation.

221 104: Mycology and Lichenlogy (40 marks)

Course outcome: Appreciation and understanding that

(i) Fungi are among the most important eukaryotic microbes on Earth. Fungi play major roles in ecosystem processes through various interactons, from the degradation of organic matter and nutrient cycling to plant symbioses and as pathogens of plants, animals, and humans.

(ii) Fungi are the most destructive pathogens of plants and play a central role in the development of plant pathology as a discipline.

Course details:

- ❖ Modern trends in classification, phylogeny and affinities and position of fungi in modern systematic.
- ❖ General account, structure organisation, ultrastructure of fungal cell, distinctive features
- ❖ Basic patterns of sexuality, heterothallism, parasexuality
- ❖ Diversity of somatic, reproductive and fruiting structures and life cycle patterns in different groups of fungi- Myxomycotina, Mastigomycotina (with special reference to sex hormones), Zygomycotina, Ascomycotina (with special emphasis on ascocarps and methods of dispersal), Basidiomycotina (with special on fruiting structures and methods of spore dispersal) , Deuteromycotina (with special emphasis on sporulating structures and conidial ontogeny)
- ❖ *Saccharomyces cerevisiae*- a model to study fungal genetics and molecular biology
- ❖ Mycorrhiza-Types and agricultural importance
- ❖ Fungi as animal & insect parasites, mycoses of vertebrate types
- ❖ Lichen – general account and economic importance; interactions of phycobionts and mycobionts

221 105: Plant Virology & Bacteriology (50 marks)

Course outcome: Upon successful completion of this course the student will be able to

-Understand the general structure and functions of the prokaryote, microbial growth and different microbial growth controlling factors and about the different types of culture media, the role of microorganisms in food and pharmaceutical industry, their sources, methods of disinfection, sterilization and preservation of food and pharmaceutical formulations.

-Understand the microbial genetics and the different diseases caused by the plant bacteria and their control.

-Understand the architecture of viruses, their classification and the methods used in their study, general replication strategies of viruses, their intricate interaction between viruses and host cells.

-Comprehend the role of viruses in improvement of the plant resistant against the plant viruses, and ways of preventing/management of the viral infections.

-Comprehend the plant viruses that can be used as tools to study biological processes, such as cloning vectors and for gene transfer.

-Comprehend the different assay and purification techniques of the plant viruses.

Course details:

- ❖ Early history & milestone discoveries in Microbiology
- ❖ Bacteria structure and function Prokaryote taxonomy- Classification of prokaryotes, characters used in prokaryote identification, current classification, bacterial diversity. Prokaryote cell structures-Eubacteria and Archaebacteria. Bacterial movement and chemotaxis. Bacterial growth in

liquid medium, growth curve growth factors, kinetics of growth and cell cycle. Types of culture media (batch and continuous, synchronous, enrichment culture).

- ❖ Microbial growth control -disinfectant antiseptic and chemotherapeutic agents-a brief account of their types and mode of action.
- ❖ Bacterial genetic mutation, mutagenesis, recombination and transposition, DNA repair mechanisms, Plasmids, F plasmids and conjugation. Transformation and transduction.
- ❖ Bacteria in the Environment Bacterial Plant pathogen, types, diseases and mechanisms of pathogenesis- an introduction.
- ❖ Principles of Plant Viral Taxonomy, Classification, origin and evolution. Some common plant diseases and disease resembling virus diseases. Learn and apply techniques for plant virus diagnosis and characterization
- ❖ Principles of plant viral structure and genetics. Virus replication, variability, transmission, movement and host range. Host response to plant infection. Small nucleic acid molecules that cause or modify diseases.
- ❖ Different vectors of plant viruses & Epidemiology, Plant virus as vector.
- ❖ Principle techniques of study Assay and purification of virus particle, Virus induced gene silencing (VIGS).

Suggested books for reading:

1. **Phycology:** Robert Edward Lee, 3rd Edition.
2. **Algae: An Introduction to Phycology:** Christissn Hoek, D.G.Mann, Hans Martin Jahns.
3. **Algal Culturing Techniques:** edited by Robert A. Andersen
4. **The Fifth Kingdom:** Bryce Kendrick, 3rd edition
5. **Bryophyte Biology:** A. Jonathan Shaw & Bernard Goffinet, 2nd edition.
6. **Mosses, liverworts and hornworts: status survey and conservation action** Tomas Hallingbac, N.G.Hodgetts, IUCN/SSC
7. **Introduction of Plant Viruses:** Mandahar, C.L.Chand & Co. Ltd. Delhi.
8. **Introduction to fungi:** Webster, J. Cambridge University, Press.

221 106-PRACTICALS (50 marks)

Course outcome: This laboratory course aims at making the student familiar with the diversity of algae, bryophytes, fungi, oomycetes, bacteria and viruses in various habitats, their identification using both morphological and modern molecular techniques including use of phylogenetic software/(s). The students will also be acquainted with various commonly used molecular biology techniques in plant sciences.

Course details:

Algae:

- Study of morphological diversity of freshwater and marine algae (depending upon the available specimens) and drawing under drawing prism with magnification and measurement.
- General principles of culturing algae in Laboratory and growth measurement.
- Algal chromosome study from *Chara.*

Fungi:

- Morphological and reproductive structure of some macro and micro fungi with drawing under drawing prism with magnification and measurement.
- Study of hyphal system of basidiocarp.

Bryophytes:

- Studies of morpho-anatomical features of vegetative and reproductive organs and diagnostic characters of some taxa of *Jungermanniales. Anthocerotales, Sphagnales* and *Bryales.*

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SEMESTER-II

221 201: PLANT SYSTEMATICS (50 marks)

Course outcome: The course will equip the student to
(i) Understand the origin and diversification of flowering plants.
(ii) Familiarity with the advanced aspects of the principles of taxonomy (identification, nomenclature, classification of flowering plants), evolution (speciation, reproductive biology, adaptation, convergence, biogeography), and phylogenetics (phenetics, cladistics, morphology and molecules).
(iii) Do systematic survey of plant families, understand the evolutionary processes and patterns in the major families and develop expertise on the representative families and local flora.

Course details:

- **Taxonomic evidences and concepts of characters:** Palynology, phytochemistry, ultrastructure and molecular characters in relation to taxonomy
- **Botanical Nomenclature:** ICBN, changes, addition and alteration of latest codes; rank of taxa and the names of taxa; priority; effective and valid publication; citations of authors; changes and rejections of names.
- **Major systems of angiosperm classification:** Outline of classification of Cronquist (1988), Takhtajan (1997) and Thorne (2007) up to sub-classes/ super orders. Broad outlines of Angiosperm Phylogeny Group (APG) II, 2009 with the line concept of Magnollids, monocots, Commelinids, eudicots, core eudicots, Rosids, Fabeids, Malvids, Asterids, Lamiids and Campanulids.
- **A general survey of the following orders of angiosperms (*Sensu* Cronquest, 1988)** with salient features, inter relationships, evolutionary trends and economic importance: Magnoliales, Caryophyllales, Nepenthales, Podostemales, Asterales, Orchidales, and Liliales.
- **Biosystematics**: Definition, methods, categories, relationship and differences with classical taxonomy.
- **Numerical taxonomy :** Principles, methods, merits and demerits
- **Phylogenetic taxonomy**: Nature of phylogeny; heterobathmy, polarity and morphocline; anagenesis and cladogenesis; pleisomorphy, apomorphy, synapomorphy, symplysiomorphy; parallelism and convergence; monophyly, paraphyly, polyphyly; importance of homology, polarizing characters of homology, homoplasy and problems of homoplasy; polygram and cladogram, Cladistic system of classification of angiosperms, basic principles.
- **Species/genes/family and other categories**: Cladistics and adaptive radiation, microevolution: theory and concepts; species and speciation; Phylogenetic systematics ; Macroevolution inferring phylogenies.

- **Molecular Systematics:** Plant genomes, nuclear, mitochondrial, chloroplast; Molecular markers; generating molecular data; restriction site mapping; gene sequencing; analysis of molecular data; alignment of sequences; methods of phylogeny reconstruction.

Suggested books for reading:

1. **Plant Biosystematics:** Grant W.F., Academic Press, London.
2. **New Concepts in Flowering Plants Taxonomy:** Harrison, H.J., Hieman Educational Books, LTD. London.

221 202: PLANT ECOLOGY & ENVIRONMENTAL BIOLOGY (50 marks)

Course outcome: This course familiarizes the students about issues of plant ecology and the environments. The environmental interaction of plant system is being taught here through this course. The interspecies competition, resilience study, biodiversity assessment, themes of conservation based on ecology are the major areas of study that will introduce students to the state of the art knowledge about ecology and environment. Students will be really benefitted by learning about this very contemporary branch of botany.

Course details:

Plant Ecology:

- **The environment:** Physical environment; biotic environment, biotic and abiotic interaction.
- **Habitat and Niche**: Concept of habitat and niche; niche width and overlap, fundamental and realized niche; resource partitioning; character displacement.
- **Environmental concepts**- low and limiting factors, ecological models; characteristics of a population, population size, exponential growth, growth curves, population dynamics; population regulation; life history strategies (r and k selection); fertility rate and age structure, concept of metapopulation-demes and dispersal; inter-demic extinction.
- **Species interaction**: types of interactions, inter-specific competition, herbivory, carnivory, pollination, symbiosis, scramble and contest competition model; mutualism and commensalisms, prey-predator interactions.
- **Ecosystem**: structure, function; primary production and decomposition, energy flow and mineral cycling (CNP), biochemical cycles; resilience of ecosystem, ecosystem management; biosphere, biomes and impact of climate on biomes; structure and function of some Indian ecosystems; terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).
- **Applied ecology**: Environmental stresses and their management; global climatic pattern and variation over time; global climatic changes and global warming, atmospheric ozone, acid and nitrogen deposition, coping with environmental variations, environmental pollutants, air, water and soil pollution, chemical fate and transport in air, water and soil. Use of fertilizer, pesticides and other chemicals in agriculture, hygiene and their disposal; chemical usage and disposal from industry and pollution, impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health, Biodegradation and bioremediation of chemicals, environmental issues, policies and regulation.

Environmental Biology:

- **Biodiversity and conservation**- assessment, monitoring and documentation, conservation and biodiversity management approaches, biodiversity act of India and related international conventions, sustainable development, nature

resource management in changing environment; molecular ecology, genetic analysis of single and multiple population, phytogeography, molecular approach and behaviour ecology, conservation genetics, Indian case studies on conservation/ management strategy (Project Tiger, Biosphere reserves).

- **Community ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
- **Ecological succession**: types; mechanisms; changes involved in succession; concept of climax.
- **Biogeography**: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

221 203: PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY & PALYNOLOGY (50 marks)

Course outcome: Completion of the course will
(i) familiarize the student with diversity of the major life forms of pteridophytes and gymnosperms as well as their fossil members. Their biology, phylogeny, interrelationships, role in environment as well as their commercial uses and industrial applications.
(ii) equip the student to understand the evolutionary interrelationships between these groups and angiosperms both from extant and extinct genera.

Course details:

Pteridophytes

- Morphological diversity and evolution of vegetative organs in Pteridophytes.
- Diversity of ferns- an ecological perspective, endangered, endemic pteridophytes and their conservation.
- Genetics and reproductive biology of ferns: polyploidy, apospory, apogamy, apomixis and hybridisation; genetic variability in fern population, genetic load.
- Culture of fern gametophyte for experimental investigation, sex determination of femaleness in free sporing heterosporous plants.
- Chemical nature and mode of action of *Antheridogens.*
- Photomorphogenesis.
- Model system in *Ceratopteris, Selaginella moellendorfii, Osmunda* and *Marsilea.*

Gymnosperms

- Evolution of pollination mechanisms and embryogeny of gymnosperms with reference to Cycadales, Coniferales, Ginkgoales, Taxales and Gnetales.

- ❖ Propagation of conifers using plant tissue culture approches, advances in synthetic seeds technology of conifers, somatic embryogenesis and plantlet regeneration.
- ❖ Acclimatization and adaptive responses to conifers to environmental stresses.
- ❖ Drought tolerance and cold hardiness, stimulation of reproductive growth seed and seedling ecology.
- ❖ Litter decomposition rate.
- ❖ Conifer plantation as seed trap, impact of coniferous forest on human life.

Palaeobotany

- ❖ **Basic geological information related to Palaeobotany**: Major types of rocks and rock cycle, sedimentary rocks, taphonomy, nomenclature and reconstruction of fossil plants, principles of stratigraphy, basic concepts of continental drift and plate tectonics.
- ❖ **Dating of rocks**: Principles of relative and absolute dating of fossils.
- ❖ **Origin and evolution of plant life forms**: Brief idea of origin of life; first prokaryotes; evolution of eukaryotes; geological records of algae (stromatolites, diatoms, dinoflagellates), fungi (endomycorrhiza and epiphyllous fungi), bryophytes.
- ❖ **The colonisation of land:** Land adaptive features, evolution of land plants and different evidences.
- ❖ **Emergence of seed plants**: Preovules, hydrasperman reproduction, evolution of closed carpels, evidences from the ovulate fructifications of Glossopteridales, Corystospermales Caytoniales, Bennettitales, Pentoxylales.
- ❖ **Appearance of Angiosperms**: Evidence for the first angiosperms, leaves, flowers and pollen grains; place of origin and radiation

Palynology

- ❖ Branches of Palynology; spore, pre-pollen and pollen morphology, wall chemistry, evolution of aperture types, application of neopalynology and palaeopalynology, ancient DNA and other fossil biomolecules in evolutionary research.

221 204: PLANT PATHOLOGY & CROP PROTECTION (50 marks)

Course outcome: By the end of the course, the students will be able to:

i. Understand the importance of diseases caused by representative pathogens
ii. Understand the molecular mechanism of host –pathogen interaction and disease resistance, and its translational use for the development of disease resistant plants through genetic engineering
iii. Identification of the diseases based on the symptoms and their control measures Understanding of disease control strategies with special reference to principles of plant viral disease management

Course details:

Plant Pathology

- History and present status of plant pathology. Production, liberation and dispersal of inoculum, inoculum potential, factors affecting inoculum potential.
- **Mechanism of disease resistance**: Morphological, anatomical and biochemical, host defence mechanisms against pathogens and pests, basal resistance, systemic acquired resistance, induced systemic resistance. Gene for gene hypothesis. Cloning of resistance genes (R genes) and avirulence genes (Avr) genes from plants and pathogens, induced response to herbivores, genetic engineering for the production of resistance plants to pathogens and pests.
- Host-pathogen interaction: penetration and disease development, role of cell-wall degrading enzymes and toxins, recognition mechanism and signal transduction during plant pathogen interaction.

Crop Protection

- **Control of plant diseases**: exclusion, eradication, protection and therapy; fungicides- inorganic and organic; protectants and systemic fungicides and their mode of action; cultural and biological control. Virus Induced gene silencing.
- **Study of the following diseases with reference to occurrence, symptoms, disease cycle and control measurements**: Blast disease of Rice, Sheath blight of rice, Bacterial blight of rice, Black stem rust of wheat, Early blight and mosaic disease of Potato, Wilt of Pigeon pea, White rust of Mustard, Anthracnose of Jute, Bacterial and Fungal Vascular wilt, Red rot of sugarcane, Citrus Canker, Tikka Disease of Groundnut, Little leaf of Brinjal, Root knot of Tomato.
- **Case studies of Host-pathogen interaction economically important causative agents with specific references to crop plants:** Plant virus interactions – Potyvirus and horticultural crops; plant bacterial interactions- *Ralstonia solanacearum* and solanaceous crops; plant nematode interactions- *Meloidogyne* sp. and tomato; Plant Oomycete interaction- *Phytophthora*-potato/ soyabean interaction; Plant insect interactions- *Pieris* sp. and crucifers; Plant Fungi interaction-*Magnaporthe grisea* and rice.
- **Principles of Plant Viral Disease Management**.

221 205: PRACTICALS:

Course outcome: The student will be equipped to

(i) Handle and analyze plant and diseased materials in the laboratory/herbarium and in the field. (ii) Use scientific terminology accurately through effective oral and written communication and the use of dichotomous keys in a regional floristic manual (iii) Have expertise in techniques related to plant pathology and plant fossils as well as their handling techniques

Course details:

Plant Systematic:

- Workout of plant specimens and description of vegetative and reproductive characters from representative locally available families. Classification based on APG III, 2009: Basal Angiosperm and Magnolids: Monocots: Commelinids: Basal Eudicots and Lamids, Campanulliids, Rosids, Asterids.
- Training in using local floras and other literature and herbaria for identification of specimens described in the classes.
- Study of different taxa, selection of key characters and preparation of keys at generic and specific level.
- Phylogeny analysis using PAUP.
- Cladogram construction and analysis
- Techniques in molecular systematic
- Field excursion for familiarization with and study of vegetative types (s) and flora(s) of areas outside and with the state and training in collection and preservation methodologies.

Plant Ecology and Environmental Biology:

- Study of morphological and structural adaptation of locally available hydrophytes , mesophytes, halophytes, and epiphytes and correlate to their particular habitats.
- Hydrophytes: *Nymphaea, Hydrilla*

  Xerophyte: *Nerium, Casuarina*

  Mesophyte: *Tridax, Vernonia*.

  Halophyte: *Avicennia, Rhizophora*.

  Epipdhyte: *Vanda*
- Assessment of density, frequency and abundance of plants in a community using various techniques i.e. transect, quadrat etc.
- Field trips for study and observation of vegetational types under the guidance of a teacher.
- Map of the phytogeographical region of India.

- Study of some endangered plant species and their conservation.
- Understanding ecosystem succession by studying various stages of vegetation/community assemblages development.
- Principle of GIS and RS technology
- Basic GIS, Visual interpretation of different types of vegetation. Delineation of ecosystems using GIS technology, temporal dynamics and models.

Gymnosperms:

- Study of leaf and wood anatomy of available specimens.
- Study of male and female reproductive structures of available specimens.

Pa**laeobotany and Palynology:**

- Study of types of Fossil and Modes of preservation.
- Study of fossil gymnosperms, pteriodophytes and angiosperms from available specimens.
- Techniques of study of plant fossils: Thin section method, peel techniques, maceration of peat, lignite and coal.
- Acetolysis of honey sample and its characterization.
- Preparation of palynological slides by acetolysis method from fresh and dry spore and pollen sample.

Plant Pathology and Crop Protection:

- Sterilization and incubation principles and uses of instruments.
- Culture media and their preparation.
- Preparation of stabs, slants and pouring of plates
- Isolation of pathogen from diseased tissue (leaf, stem and fruits) their culture.
- Preparation of pure culture and sub culturing.
- Study of mycorrihza from root and soil.
- Inoculation of tuber, stem and fruit.
- Study of production of organic acid/ alcohol/ enzyme.
- Molecular detection and identifications of phytopathogens.
- Biological control by dual culture technique.
- Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens and their drawing under drawing prism with magnification and measurement.
- Field visit to show diseases on crop plant.

SEMESTER-III

221 301: MOLECULAR & CELLULAR GENETICS (50 marks)

Course outcome: On successful completion of the course students will:
(i) Have a solid foundation in modern molecular genetics as the focus is on understanding central principles and fundamental mechanisms for the organization, replication, expression, variation, and evolution of the genetic material at a molecular level, as well on methods for molecular genetic analyses and gene technology
(ii) Have an advanced understanding of the modern concept of gene, methods to study them along with their model systems, their changes in frequency and structure as well as its regulation.
(ii) Have an understanding of transmission genetics (including linkage analysis), quantitative genetics and population genetics.
(ii) Have an in depth exposure and analyses of various modern tools and instrumentation techniques used in molecular biology, cytogenetics and plant breeding.
(iii) Have the skills necessary for critically reviewing scientific papers and general media presentations, for retrieving and analyzing molecular information as well as skills for interpreting genetic data on issues related to molecular biology as the main theme of the course is to understand molecular genetics as an experimental discipline.

Course details:

- **Cytogenetic aspects of cell division**: Chromosome labelling and cell cycle analysis, Overview of mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle, sister chromatid cohesion remodelling, regulation of exit from metaphase, chromosome movement at anaphase, genetic control of meiosis with example from yeast.
- **Concept of gene**: Fine structure of gene, split genes, overlapping gene, pseudogene and cryptic genes and multigene family.
- **Model systems in Genetic Analysis:** Lambda phage, *E. coli*, *Neurospora crassa*, Yeast, *Arabidopsis*, Maize, Rice.
- **Sex linked inheritance**: Sex chromosomes and sex determination in plants, sex linked inheritance.
- **Quantitative inheritance**: Concept, genes and environment- heritability, penetrance and expressivity.
- **Cytoplasmic inheritance** : Basis and mechanism, role of organellar genes
- **Chromosome organization**: Metaphase chromosome: centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes; Heterochromatin and euchromatin, position effect variegation; chromosomal domains (matrix, loop domains) and their functional significance
- **Chromatin structure:** Histones, DNA, nucleosome morphology and higher level organization; functional states of chromatin and alterations in chromatin organization.

- **Mutation**: Molecular basis of gene mutation, Transposon mutagenesis, site-directed mutagenesis, environmental mutagenesis, in vitro mutagenesis, DNA damage and repair mechanism.
- **Chromosomal anomalies**: Numerical and structural alterations, induced chromosomal aberrations in somatic cells.
- **Changes in Chromosome number and structure**: Polyploidy, aneuploidy, chromosomal rearrangements- deletion, duplication, inversion, and translocation. Meiotic consequences in structural heterozygotes.
- **Specialized Chromosomes**: Polytene, lampbrush and B chromosome
- **Techniques in the study of chromosomes and their applications**: Karyotype concept, principle of chromosome banding technique, chromosome labeling, in situ hybridization, GISH and FISH techniques, chromosome painting.
- **Organization and measure of genetic variation:** Random mating population, Hardy-Weinberg Principle, complications of dominance, special cases of random mating- multiple alleles, different frequencies between sexes (Autosomal and X-linked).
- **Linkage and crossing over:** Linkage, crossing over and chromosome mapping: Crossing over as the physical basis of recombination; chromosome mapping; three point test cross, construction of genetic and physical map; molecular polymorphism.
- **Sources responsible for changes in gene frequencies**: Mutation, selection, migration and isolation; random genetic drift. **Regulation of Gene Expression in Prokaryotes:** Lactose, Tryptophan, Arabinose, Histidine Operon Systems of E. coli, Lambda lytic and lysogenic Regulatory Cascade, Translational Control of Gene Expression.
- **Regulation of Gene Expression in Eukaryotes**: Induction of Transcriptional Activity by Environmental and Biological Factors, Transcription Factors, Gene Expression and Chromosome organization.

221 302: PLANT BREEDING **(50 marks)**

Course outcome: On successful completion of the course students will:
(i) An understanding about the need for plant breeding, and the methodologies used
(ii) Have an advanced understanding of the genome mapping strategies and molecular plant breeding strategies.

Course details:

- **Plant breeding**
  - History, genetic diversity in plant breeding
  - Natural breeding systems in plants and their application in plant breeding

- Conventional breeding methods for self, cross-pollinated and vegetatively propagated crop plants
- Heterosis breeding: Hybrid vigour
- Polyploidy and haploids in plant breeding
- Cytogenetics tools in Plant breeding
- Seed production and variety development

❖ **Marker assisted breeding**: molecular markers as new efficient tools in breeding. VNTR, STR, SSR, ISSR, microsatellite, SNP, and their detection techniques- RFLP, genotyping, RAPD, AFLP etc.

❖ **Plant Genome mapping:** Physical maps an over view and approaches.

❖ **Evolution study through genomic approach**

❖ **Dissection of quantitative traits**: Principles and methods of QTL mapping.

❖ **Study of molecular markers for studying genetic variation:** Marker assisted breeding: gene tagging, marker aided selection, all types of molecular markers and their utilization in molecular breeding.

221 303: PLANT PHYSIOLOGY & BIOCHEMISTRY (50 marks)

Course outcome:

This course covers the general aspects of plant physiology and biochemistry. Plants maintain a very unique physiological system through photosynthesis, photorespiration, nitrogen fixation, plant specific growth hormonal control etc. and we introduce students to that specific arena through this course. Students will acquire the basic physiological and biochemical knowledge of plant systems that will help them build up their further concepts and will be knowledgeable enough to choose their elective courses in the next semester depending upon their understanding about the relevant subject.

Course details:

- Apoplastic and symplastic transport mechanisms, role of aquaporins and transporter proteins, structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity, specialized mechanisms for phosphorus and iron uptake, monitoring of ion channel activity.
- **Photosynthesis**: complexes of electron transport in chloroplast , mechanism of electron transport generation of proton gradient and ATP generation, bioenergetics of light reaction, CO_2 concentrating mechanism in plants, regulation of C_3- C_4 and CAM cycles
- **Respiration and photorespiration**: metabolic regulation of glycolysis, acetyl CoA , Kreb's cycle, gluconeogenesis and glyoxylate cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
- **Nitrogen metabolism**: Nitrate and ammonium assimilation; amino acid biosynthesis: structure and function of nitrogenase, *nif* gene and *nod* gene organization
- **Protein structure**: Hierarchical structure of proteins; folding; ticketing; degradation; purification, detection and functional characterization; sequence alignments; molecular motors and pumps. Ramachandran plot.
- **Enzymes and bioenergetics**: Application of principles of thermodynamics in biology; origin and evolution of biocatalytic reactions; significance of ribozymes; abzymes; artificial enzymes; enzyme technology; regulation of enzymatic activity; evolution of electron transport chain and its coupling to ATP synthesis.
- **Sensory Photobiology**: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement;
- **Plant hormones**: Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action and use of mutants in understanding hormone actions, hormones in defense against abiotic and biotic stresses, synthetic regulatory compounds and their uses.

- **Stress physiology**: Responses of plants to abiotic (water, temperature and salt) stresses; Formation of ROS and its role in plants defence. Signalling in plant.
- **Senescence and programmed cell death (PCD):** Basic concepts, types of cell death, PCD in life cycles of plants, metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence.

221 304: PLANT DEVELOPMENTAL BIOLOGY & ANATOMY (50 marks)

Course outcome: This is an upcoming research area in the field of plant science. Though the subject is still young, we intend to expose our students to the state of the art knowledge about this specific section. Plant developmental studies with identification of the genes associated with the developmental events are mostly carried out in model species and this area of study is mainly based upon mutant generation. We expect the students will admire this fascinating area which is highly relevant at the present scientific world and will benefit from this study.

Course details:

- **Seed germination and seedling growth:** Metabolism of nucleic acids, proteins and mobilization of food reserves; tropisms; use of mutants in understanding seedling development; orthodox and recalcitrant seeds, types of seed dormancy, breaking of dormancy, biochemical changes during dormancy.
- **Shoot development**: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication ; control of tissue differentiation , especially xylem and phloem; secretory ducts and laticifers; wood development in relation to environmental factors.
- **Leaf growth and differentiation**: Determination, phyllotaxy, control of leaf form ; differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll.
- **Root development**: Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots; root hairs.
- **Reproduction**: Vegetative options and sexual reproduction; transition to flowering; floral meristem and flower development; genetics of floral organ differentiation; homeotic mutants and floral development in *Arabidopsis* and *Antirrhinum* and Rice; sex determination; mutants and transgenics in analysis of development.
- **Male gametophyte**: microsporogenesis, role of tapetum ; pollen development and gene expression; male sterility; sperm dimorphism and hybrid seed production;
- **Female gametophyte**: Ovule development; megasporogenesis; organization of the embryo sac, structure of embryo sac cells.

- **Pollination, pollen-pistil interaction and fertilization**: Breeding systems; commercial considerations; structure of the pistil; pollen-stigma ineractions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects); double fertilization (structural and molecular aspect); *in vitro* fertilization.
- **Seed and fruit development**: Endosperm development during early, maturation and desiccation stages; embryogenesis, ultra structure and nuclear cytology; cell lineages during late embryo development; establishment of symmetry in plants; storage proteins of endosperm and embryo; polyembryony; apomixis; apospory; embryo culture; dynamics of fruit growth; biochemistry and molecular biology of fruit ripening and maturation.
- **Latent life- dormancy**: Importance and types of dormancy; seed dormancy; overcoming seed dormancy, bud dormancy.

221 305: PRACTICALS:

Course outcome: This practical course is intended for the students to give them hands-on training to different experiments on Molecular biology, Cytogenetics and Plant breeding as well as on plant physiology, biochemistry and plant developmental studies. It is intended to develop technical capability in the selection and use of appropriate laboratory and other materials and equipment and the ability to employ them in a safe and responsible manner to achieve the desired outcome. This will include the ability to follow standard operating procedures which will benefit them greatly in pursuing further research.

Course details:

Molecular & Cellular Genetics:

- According to theoretical syllabus

Plant Breeding:

- According to theoretical syllabus.

Plant Physiology and Biochemistry:

- According to theoretical syllabus.

Plant Developmental Biology and Anatomy:

- According to theoretical syllabus.

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SEMESTER-IV

SPECIAL PAPERS

221 401a & 221 401b: PLANT VIROLOGY, MOLECULAR MYCOLOGY & PLANT PATHOLOGY

Special Paper-I:

221 401a: Plant Virology & Molecular Mycology (75 marks)

Course outcome: Upon successful completion of this course the student will be able to

(i) Understand the economic and pathological importance of plant viruses, their nature and properties, classification, knowledge how the virus evolution takes place as well as those of virus-like entities, the role of satellite viruses and satellite RNAs and viroid in plant diseases.

(ii) Understand the different diseases caused by the viruses, symptomatology, transmission, purification, assay, characteristics and control measures of representative viruses.

(iii) Understand the diversity and role of Fungi and Oomycetes in the environment, their biology, interrelationships, genome organization, commercial uses and the biological resources available for their study.

Course details:

Plant Virology

- Nature and properties of viruses and virus-like entities. Symptomatology, transmission, purification, characters and classification of Potyvirus, Potexvirus, Geminivirus, Tospovirus, Tobamovirus.
- Transmission of plant viruses: Seed, pollen, soil, water and vegetative materials; Vector transmission by organisms other than arthropods. Arthropod transmission - types and characteristics, mechanisms and accessory factors.
- Plant virus based vector
- Viruses and Virus Diseases of Plants.
  - ss(+)RNA viruses. Detailed examples: Tobamoviruses, Potyviruses, Closteroviruses
  - ss(-)RNA and dsRNA viruses: Detailsed examples: Rhabdoviruses and Reoviruses, Tosposviruses and Tenuiviruses
  - ssDNA and dsDNA viruses:Detailsed examples: Geminiviruses and Nanoviruses, Caulimoviruses
- Satellite viruses, satellite RNAs, and Viroids.
- Variability of plant viruses and strains; Evolution of plant viruses.

Molecular Mycology

- Origin of fungi and their interrelationships; modern methods of classification.
- Role of sex hormones in reproduction of fungi
- Genetic variation in fungi: Heterokaryosis, parasexual cycle and their significance; Detection of genetic variation in populations.

- ❖ Adaptations in Fungi: Thermophilic fungi, Photoresponses and Circadian rhythm, Role of saprotrophs in ecosystems.
- ❖ Nutrient sensing and uptake in fungi: Regulation of carbohydrate and nitrogen compound metabolism.
- ❖ Genetic control of vegetative growth, asexual, sexual development and senescence.
- ❖ Genome organization in fungi: Extra chromosomal inheritance in fungi; Retroposon and retrotransposon in fungi.
- ❖ Principles and general methods of gene manipulation in fungi.
- ❖ Regulation of protein synthesis in fungi; Heat shock protein and chaperon.
- ❖ Signal transduction pathway.
- ❖ Culture repositories and methods of preservation of fungal cultures; Mycological databases; GeneBank repositories, open source computational and other internet resources for Mycologists and Plant Pathologists; searching and retrieving from databases.

Special Paper -II

221 401b: Plant Pathology (75 marks)

Plant Pathology

Course outcome: On completion of the course the student will be knowledgeable about (i) Principles of the epidemiology of diseases, molecular basis of how pathogens attack the plants and hijack their defences, how the plants perceive the pathogens and react to infection.

(ii) sustainable control methods, chemical control and their risks, modern methods of development of diseases resistant varieties.

Course details:

- ❖ Epidemiology of plant diseases: Disease pyramid-components, measurement and simulation of plant disease epidemics; forecasting and remote sensing. Epidemiology and ecology of plant viruses.
- ❖ Molecular basis of plant-pathogen interaction- physiology and genetics of plant-pathogen interaction; genetics of pathogenicity; gene for gene hypothesis and its molecular explanation; resistance genes and avirulence genes; Effector molecules and receptors, Modern methods of transcriptome analysis.
- ❖ Host specific and non specific toxin and molecular basis of their roles in pathogenicity.
- ❖ Molecular biology of disease resistance- Plant chemicals (phenolics) involved in resistance: Hypersensitve (HR) reactions, Phytoalexins; pathogenesis related (PR) proteins, systemin; systemic acquired resistance (SAR), Induced Systemic resistance (ISR) and Pathogen-associated molecular patterns (PAMPs) and also Reactive Oxygen species (ROS).

- ❖ Development of disease resistant variety by mutation breeding and recombinant DNA technology; RNAi in plant pathology.
- ❖ Serological methods for detection and characterization plant pathogens: Immunological assays.
- ❖ Molecular diagnoses of plant pathogens- DNA-DNA hybridization; PCR amplification and finger printing.
- ❖ Fungicides in disease control; topical and systemic fungicides, mechanism of fungicidal action- mode of action of systemic fungicides (belonging to some common chemical groups), application of fungicides.
- ❖ Biological control by biotechnological methods- use of hyper parasite, hypovirulence plasmids and recombinant DNA technology.
- ❖ Control of plant virus diseases; Biotechnology/genetic engineering; VIGS
- ❖ Integrated disease management.

Suggested books for readings:

1. **Biochemistry & Molecular Biology of Plants** by Russell L. Jones, Bob B. Buchanan , Wilhelm Guissem John Wiley & Sons. American Society of Plant Biologists.
2. **Crop Diseases and their Management** H.S. Chaube, V.S. Pundhir.Prentice Hall India Eastern Economy Edition
3. **Dictionary of the Fungi, 10th Edition** (September 2008) Edited by P M Kirk, CABI, UK; P F Cannon, CABI, UK; D W Minter, CABI, UK; J A Stalpers, CBS, Netherlands.
4. **Fungal Genetics**, David Moore, Lily Ann Novak Frazer, Springer (Indian Reprint) 2005
5. **Fungal Biology,** Deacon, Jim, Blackwell Publishing**,** 2005
6. **Fungal Morphogenesis,** Moore, David**,** Cambridge, 2002
7. **Fungi, Experimental Methods in Biology**, R. Maheswari, CRC Press, Taylor and Francis, 2005.
8. **Illustrated Dictionary of Mycology** by Miguel Ulloa and Richard T. Hanlin 2000; APS Press.
9. **Introduction to Fungi** John Webster with Roland W. S. Weber
10. **Introduction to Plant Pathology** Strange, RN (ed.): J. Wiley & Sons Ltd, Chichester, UK, 2003.
11. **Matthews' Plant Virology,** Roger Hull (Fourth Edition) 2002 Elsevier Ltd.
12. **Molecular Plant Pathology,** M. Dickinson (Division of Plant Sciences, University of Nottingham) Paperback Bios Scientific Publishers Ltd. **Plant Pathology** G. N. Agrios
13. **Plant Associated Bacteria,** Eds. Samuel S. Gnanamanickam, 2007, Springer, The Netherlands.
14. **Recent Advances in Plant Virology**, Edited by: Carole Caranta, Miguel A. Aranda, Mark Tepfer and J.J. Lopez-Moya, Caister Academic Press, 2011
15. **The Fifth Kingdom** Third Edition (Paperback) by Bryce Kendrick
16. **The Fungi** Second Edition by Michael J. Carlile, Sarah C. Watkinson, Graham W. Gooday

17. **The Identification of Fungi: An Illustrated Introduction with Keys, Glossary, and Guide to Literature** by Frank M. Dugan APS Press.

Related review articles in the following Journals:

- Trends in Plant Science,
- Trends in Biochemical Sciences,
- Theoretical and Applied Genetics,
- PNAS,
- Current Science,
- Bioassays,
- Current Opinion in Plant Biology,
- Fungal Genetics and Biology,
- Phytopathology,
- Annual Review of Phytopathology,
- Plant pathology,
- Mycologia,
- Molecular Plant pathology.

Semester- IV

221-405: Practical

According to theoretical syllabus in Special paper-I & II

221 402a & 221 402b: MOLECULAR GENETICS, ADVANCED CELL BIOLOGY, APPLIED PLANT BREEDING AND PLANT TISSUE CULTURE

Special Paper-I

221 402a: Molecular Genetics & Advanced Cell Biology (75 marks)

Course outcome: On completion of the course the student will know about

(i) Genetic information and the different molecular aspects of the genome, regulation of the expression of genetic information, maintenance, organization and evolution.

(ii) Advanced knowledge of cell biology, protein sorting, trafficking, signaling as well as proteomics and its application in modern day biology.

(ii) The latest discoveries in gene technology, including RNA biology and gene editing technologies.

Course details:

Molecular Genetics

- **Pigmentation Genetics in higher plants-** Different types of pigments, pigment formation in Maize, Flower colour inheritance in Dahlia.
- **Self-incompatibility-** Basic Concept, Heteromorphic and Homomorphic Systems, Mechanisms of Self-incompatibility, Overcoming Self-incompatibility.
- **Male Sterility-** Induction of male sterility, utility, Mechanisms, Types of Male Sterility, Maintenance of Male sterile line.
- **Replication of Chromosome Termini**- Telomerase, Telomere length and Aging in Human .
- **Cell Cycle & Cancer** - Genetic Basis of Cancer, Oncogenes, Tumor Suppressor genes, Cellular roles of Tumor Suppressor proteins, Genetic pathways to cancer, Programmed Cell Death (PCD).
- **RNAi Biology-** Discovery of RNA interference; categories of small non-coding RNAs- dsRNA, siRNA, shRNA, piRNA, miRNA, Mechanism of RNAi, Expression of dsRNA in plants and its applications- analysis of expression of dsRNA and gene silencing, use of RNAi in crop improvement, RNAi therapy.
- **Genomes and Genomics** – An overview, Genome sequencing strategies, genomes of Yeast, *Arabidopsis*, rice and human, Genome annotation, Genome Duplication, Approaches to analyze differential gene expression- ESTs, Microarrays and their applications, Reverse genetics- Gene tagging, Gene trapping, Gene silencing, Knockout mutants, Transcriptome.
- **Proteomics**—Concept of proteome, Applications of proteomics: protein mining, protein-expression profiling, protein network mapping, protein modification and analysis.

Advanced Cell Biology

- **Membrane Transport-** Lipid bilayer, Membrane Proteins, Principles of Membrane Transport, Carrier Proteins and Active Membrane Transport, Ion Channels and Electrical Properties of Membranes.

- **Intracellular Compartments and Protein Sorting-** Compartmentalization of Higher Cells, Transport of Molecules into and out of the Nucleus, Transport of Proteins into Mitochondria and Chloroplasts, Import of Proteins into Peroxisomes. Role of SRP (Signal Recognition Particle) in directing ribosomes to the ER membrane.
- **Vesicular Traffic in the Secretory and Endocytic Pathways-** Transport from E.R. through the golgi apparatus, Role of M6P (Mannose 6-Phosphate) receptor in lysosomal enzyme sorting, Transport from the Plasma membrane via Endosomes- Endocytosis.
- **Cell Signaling-** Intracellular and Cell-Surface Receptor proteins: Ion channel linked,G-protein linked and enzyme linked.

Special Paper-II

221 402b: Applied Plant Breeding and Plant Tissue Culture (75 marks)

Course outcome: On completion of the course the student will be knowledgeable about
(i) Principles of plant breeding, different types of breeding techniques used
(ii) Principles and methods of micro and macropropagation.
(iii) Principles and application of statistics in biological research and familiarity with statistical software

Course details:

Applied Plant Breeding

- **Continuous Variation and its Significance-** Qualitative traits and Discrete variation, Quantitative Trait and Continuous variation, Polygenes and Polygenic inheritance.
- **Genotype-Environment Interaction and Adaptation-** Adaptation and Adaptability, Mechanisms of Adaptation, Homeostasis.
- **Inbreeding & Loss of Vigour-** Inbreeding mating system, Inbreeding Coefficient, Phenotypic Consequences of Inbreeding, Genetic Basis of Inbreeding in Allogamous Crops, Inbreeding for crop improvement.
- **Heterosis and Gain in Vigour-** Categories of Heterosis, Sources & Manifestation of Heterosis, Genetic Basis of Heterosis, Maximization and Fixation of Hybrid Vigour, Development and choice of seed parent (A-line) and restorer/ male parent (R-line). Problems and prospects of hybrid seed production in self pollinated crops.
- **Mutation Breeding**- Utility and accomplishment of induced mutations. Management of M1, M2 generations, Factors influencing the mutation spectrum and the quality of mutants.
- **Breeding for Disease Resistance-** Physiological races and pathotypes, Genetics of Pathogenicity, Vertical and Horizontal Resistance, Gene for Gene hypothesis, Breeding methods & limitations.
- **Synthetic variety-** Limiting factors determining performance, Maintenance of Synthetic variety.

- **Cooperative Researches & Release of Variety**- Quality Seed production and maintenance.
- **Marker Assisted Breeding**: Quantitative and qualitative traits, marker assisted selection for genes of agronomic importance, QTL mapping.
- **Principles and applications of statistical methods in biological research:** Basic statistics- Sample and population, experimental design- randomized block design, latin square design, factorial experiments, missing plot techniques, data analysis, graphs, average, co-efficient distributions (chi-square, Binomial, Poisson and Normal), Tests of significance- t-test, z-test, F-test, U-test, Regression and correlation, Analysis of variance. Data processing using statistical software.

Plant Tissue Culture

- **Concept of Plant Tissue Culture Technique**: Historical developments, Basic Requirements for Tissue Culture Laboratory, Formulation of Tissue Culture Medium, Growth regulators, Steps of tissue culture starting from culture initiation to hardening, Vitrification & morphological variation, Cellular totipotency, Embryo rescue.
- **Types of Tissue culture:** Organ culture- culture of indeterminate organs, culture of unorganized cells- callus culture, cell suspension culture, cultures of single cell origin- single cell clones, protoplast culture.
- **Bioreactors**: concept, Types of Bioreactors- Batch, Continuous, multistage and immobilized call bioreactors, Application in plant tissue culture.
- ***In vitro* Genetic Variation**: Somaclonal and gametoclonal variation, Isolation and Characterization of somaclones, Molecular basis of Somaclonal variation, Advantages of Somaclonal variation over induced mutations, Applications in crop improvement, *In vitro* mutagenesis and mutant selection.
- **Organogenesis**: Developmental sequences, Mechanism of action of plant hormones, Control of *in vitro* organogenesis by cyclin-dependent kinase activity.
- **Somatic Hybridization:** protoplast isolation technique, protoplast fusion, selection of hybrid cells- Homokaryons, Heterokaryons, Regeneration-symmetric & asymmetric hybrids, fate of plasmagenes, Cybrids.
- **Somatic Embryogenesis:** Gene expression and signal transduction during embryogeneis, General aspects of Somatic embryogenesis, conditioning factors regulating somatic embryogenesis, Tracking of Somatic embryogenesis, Artificial seeds.
- **Haploid and Triploid production**; Androgenesis, Gynogenesis and Endosperm culture; Techniques and its applications in genetics and crop improvement.
- **Micropropagation**: Principal methods & Stages of Micropropagation, Advantages & Disadvantages of this in vitro technique, Application, Production of virus-free plants by meristem culture, genetic assessment by RAPD, RFLP and ISSR markers.
- **Molecular Techniques:** Principles and applications of southern & northern.

Suggested books for readings:

1. Concepts of Genetics- Klug W.S., Cummings M.R., Spencer C.A. & Palladino M.A. (Pearson International Edition)
2. Essential Genetics- A Genomic Perspective- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
3. Genes IX- Lewin Benjamin (Jones & Bartlett publishers)
4. Genetics- A Conceptual Approach- Pierce B. (W.H. Freeman & Co.)
5. Genetics- Analysis of genes and genomes- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
6. Genetics- from genes to genomes- Hartwell (Tata McGraw-Hill Int. Edition)
7. Genetics- A Molecular Approach- Peter J. Russell (Pearson Int. Edition)
8. Molecular Cell Biology- Lodish H, Berk A, Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. & Matsudaira P. (W.H. Freeman & Co.)
9. Principles of Gene Manipulation & Genomics- Primose S.B. & Twyman R.M. (Blackwell publishing)
10. Principles of Genetics- Snustad D.P. & Simmons M.J. (John Wiley & sons Inc.)
11. Principles of Genetics- Tamarin R.H. (Tata McGraw-Hill edition)
12. Molecular Cell Biology, Lodish, Harvey; Berk, Arnold; Zipursky, S. Lawrence; Matsudaira, Paul; Baltimore, David; Darnell, J. E. New York: W.H. Freeman & Co.
13. Cell And Molecular Biology: Karp Gerald, Cbs Publisher & Distributor.
14. The Cell - A Molecular Approach, Cooper, Geoffrey M. Sunderland (MA): Sinauer Associates, Inc.
15. Molecular Biology of the Cell, Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter New York and London: Garland Science.
16. Cell and Molecular Biology: De Robertis, E.D.P. and De Robertis Jr, E.M.F. 2001.
17. Biochemistry & Molecular Biology Of Plants, Russell L. Jones, Wilhelm Gruissem, Bob B. Buchanan, John Wiley & Sons.
18. Lehninger principles of Biochemistry, Albert L. Lehninger, David Lee Nelson, Michael M. Cox, W.H. Freeman
19. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
20. Bojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations, Elsevier Science Publisher, New York, USA.
21. Collins, H.A. and Edwards, S. 1998. Plant Cell Culture, Bios Scientific Publishers, Oxford, UK.
22. George E.F., Hall M.A. and Klerk J.D. Plant Propagation by Tissue Culture (3rd Ed.), Springer
23. Khasim, S.M. 2002. Botanical Microtechnique: Principles and Practice, Capital Publishing Company, New Delhi.
24. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture, Kluwer Academic Press, The Netherlands.
25. Principles of Plant Breeding, Allard R.W., John Wiley & Sons.

26. Plant Breeding, Poehlman J.M. & Barthakur D., Oxford & IBH.
27. Plant Breeding- Principles and Methods, Singh B.D. Kalyani Publishers.
28. Principles and Practice of Plant Breeding, Sharma J.R., Tata McGraw Hill.
29. An Introduction to Plant Breeding, Jack Brown, Peter Caligari, Wiley-Blackwell
30. Molecular Marker Systems in Plant Breeding and Crop Improvement, Lörz, Horst; Wenzel, Gerhard (Eds.), Springer.
31. Biostatistical analysis, Zar JH. Englewood Cliffs, NJ. Prentice
32. Basic Biostatistics and its Application. Animesh K. Datta. New Central Book Agency (P)

Semester IV

221 405: Practical

According to theoretical syllabus in Special Paper-I & II

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221 403a & 221 403b: ADVANCED PLANT PHYSIOLOGY, BIOCHEMISTRY & PLANT MOLECULAR BIOLOGY

Special Paper-I

221 403 a: Advanced Plant Physiology & Biochemistry (75 marks)

Course outcome: This course will expose the students to advanced areas of plant physiology and biochemistry. This will enhance the knowledge of the students who are interested to pursue further research in this arena. This is an elective course and students are free to choose the course based on their admiration to the specific subject area.

Course details:

- **Programmed cell death (PCD**): Developmental and stress-induced PCD. Leaf and flower senescence. Altered metabolism during senescence and its regulation. The oxidative stress and the anti-oxidative strategies. Hormonal modulations. Environmental, genetic and molecular regulations.

- **Stress physiology:** Types of environmental stresses; plant response of abiotic stress; osmotic adjustment and its role in tolerance to drought and salinity; impact of salinity and water deficit stress on transport across plant membranes, stress-inducible proteins and genes, metal toxicity, freezing and heat stress; introduction to biotic stresses like bacteria, virus, fungi, pests etc, types of plant resistance to pathogens (R gene resistance, quantitative and monogenic), basal and induced defense mechanisms, preformed inhibitors of pathogens, gene for interaction in plant defense, Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), recognition mechanism and signal transduction during plant pathogen interaction. Biochemical mechanisms of plants' chemical war against other plants and animals. Plant responses to

herbivory; constitutive defense mechanisms; induced phytochemical responses; biochemical mechanisms of allelopathty.

- **Oxidative and nitrosative stress and antioxidative strategies**: Nitrosative and oxidative stress - causes and effects, nitric oxide biosynthesis and metabolism, NO mediated signalling, markers of nitrosative stress, NO crosstalk with other hormones, antioxidant mechanisms.
- **Genomics**: Genome sequencing strategies and programs, new technologies for high-throughput sequencing, methods for sequence alignment and gene annotation; Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications; gene tagging; gene and promoter trapping; knockout and knock-down mutants; dynamic modulation of protein structure and function; Comparative genomics of model plants and related crop species; Recombination-based cloning techniques. TAIR/SGN/GRAMENE databases.
- **Proteomics**: Comparative account of translation in prokaryotes and eukaryotes, post translational modifications, Use of vectors for over-expression of proteins, Protein extraction/purification techniques viz., electrophoresis and column chromatography, Introduction to proteome and proteomics and its relevance/significance in the post genomic era, Proteomics as a tool for plant genetics, breeding and diversity studies; Analysis of proteins by different biochemical and biophysical procedures like CD (Circular Dichroism), NMR, UV/Visible and fluorescent spectroscopy, protein identification and analysis on ExPASy server, other protein related databases, 1-D and 2-D gel electrophoresis for proteome analysis, Sample preparation, gel resolution and staining; Mass spectrometry based method for protein identification like MALDI TOF, PMF (protein mass fingerprinting) and LCMS; future directions in proteomics, scope of functional proteomics; homology modelling study.
- **Respiration and photorespiration** : metabolic regulation of glycolysis, pyruvate dehydrogenase complex, acetyl CoA , Kreb's cycle, gluconeogenesis and glyoxylate cycle; photorespiration, Compartmentalized reactions; structural and functional characteristics of Rubisco and its regulation in C-2 cycle, energetics and significance of the cycle.
- **Photosynthesis**: Detailed view of Z or N scheme, organization of photosynthetic apparatus and light absorbing antenna system, genes and polypeptide components of photosynthetic complexes, structural organization and genes involved in Rubisco and Rubisco activase, synthesis and degradation of sucrose and starch during photosynthesis, impact of senescence on photosynthesis.
- **Secondary metabolites and their biotechnological aspects**: Natural products (secondary metabolites), their range and ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis. Molecular approaches and biotechnological applications. Metabolic engineering in the production of pharmaceuticals.

Suggested books for readings:

1. **Introduction to Plant Physiology** : William G. Hopkins and Norman P.A. Huner. (Fourth Edition) 2008. John Wiley& Sons, Inc.

2. **Biochemistry & Molecular Biology of Plants:** Bob B. Buchanan, Wilhelm Gruissem and Russell L. Jones**. 2000. ASPP publication**
3. **Lehninger Principles of Biochemistry :** David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.
4. **Biochemistry**: Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. (Fifth edition). 2002. W.H. Freeman publication.

Related review articles in the following Journals:

- Annual Review of Plant Biology,
- Critical Reviews in Plant Science,
- Current Opinion in Plant Biology,
- Trends in Plant Science,
- Plant Physiology, Plant Cell,
- Annual Review of Plant molecular biology,
- Annual Review of Plant Physiology,
- Plant Molecular Biology

Special Paper-II

221 403b: Plant Molecular Biology (75 marks)

Course outcome:

This course covers the important area of plant molecular biology which has not been dealt in detail hitherto in any of the courses. This is a very relevant course and teaches the students about major areas of plant biotechnology like recombinant DNA technology, gene cloning, gene sequencing, genome projects, cloning vectors, proteomics, RNA interference, gene regulation, epigenetics etc. in a very concise and simplistic manner. This course is designed in such a way that it will benefit the students greatly to answer CSIR/UGC NET questions.

Course details:

Recombinant DNA technology:

- Isolation and purification of RNA , DNA (genomic and plasmid), analysis of RNA, DNA restriction and nucleic acid modifying enzymes, restriction mapping.
- Basics of Cloning:Various ways of cloning.Cloning into different vectors-plasmids, phages and phage derived PAC, BACs and YAC, selection and screening of clones. synthetic DNA vectors
- Methods of DNA and protein analysis: Electrophoretic techniques, Southern and Northern blotting, preparation of probes, Isolation and purification of DNA, RFLP, AFLP DNA finger printing and its application, Native PAGE, SDS-PAGE, 2-D PAGE, Isoelectric focusing gels; Western blotting.
- Transcriptional analysis of gene expression and transcriptomics: Northern blotting, RT-PCR, EST analysis, promoter analysis, mapping transcription start sites, DNA microarray.
- Overexpression of Recombinant proteins: over expression and tagging of proteins in E. coli as well as in eukaryotic systems
- F. Analysis of protein-DNA and protein-protein interaction: gel retardation assay, DNA footprinting, yeast one, two and three hybrids assay,
- Protein engineering and proteome analysis: Insertional and deletion mutadirected mutagenesis and proteome analysis
- Polymerase chain reaction: Concept, types and application
- Construction of genomic and cDNA libraries: Vectors used in the construction of cDNA versus genomic DNA libraries, steps and enzymes, screening of libraries, screening expression libraries.
- Genome sequencing:DNA sequencing by Sanger's method, Physical mapping, whole genome shotgun sequencing , BAC/YAC library, genome annotation at different level.
- Plant tissue culture and somatic cell genetics; Nutrient media; Role of phytohormones in plant development *in vitro*; Plant regeneration pathways-organogenesis and somatic embryogenesis; Protoplast culture and fusion, somatic hybrids; Organelle transfer and cybrids; Micropropagation, artificial seed and bioreactor technology, Virus-free plants by meristem culture; Use of

somaclonal and gametoclonal variation for crop improvement; *In vitro* mutagenesis and mutant selection; Preservation of plant germplasm *in vitro*.

- **Plant transformation vectors and methods:** Plant transformation vectors-T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes; Plant transformation by *Agrobacterium* sp., non-*Agrobacterium* sp. and in planta transformation; Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants- Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; Multigene engineering.
- **Applications of transgenic technology in plants**: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence; GM crops for nutritional quality and quantity; RNAi- mediated crop improvement; Molecular farming; Metabolic engineering and hairy root culture for secondary plant products; Other applications; Global status and biosafety of transgenic plants
- **RNAi Biology and its applications**: Discovery of RNA interference; categories of small non-coding RNAs-dsRNA, siRNA, shRNA, piRNA, miRNA; Mechanism of RNAi; Expression of dsRNA in animals and plants and its applications- analysis of expression of dsRNA and gene silencing, use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy.
- **Gene regulation**: Regulation of prokaryotic gene expression (lac, his, trp, ara operons and catabolite repression); Regulation of gene expression in eukaryotes (in Yeast Gal gene), transcriptional control (changes in chromatin structure, epigenetic control, transcription factors), epigenetic gene regulation (DNA methylation, histone modifications, epigenetic control of transposons and repetitive elements, imprinted genes), methods for analyzing epigenetic marks (post transcriptional regulation, regulation of translation and post translational modification), RNA- mediated control of gene regulation, heterochromatin in gene silencing.
- **Molecular biology of Recombination**: Homologous and non-homologous recombination, including transposition, site-specific recombination. McClintock and the Ac/Ds transposable elements of corn; Cloning maize Ac/Ds elements; molecular features of the maize Ac/Ds system; Tansposon tagging of plant genes, Cloning the Cf-9 gene of tomato by transposon tagging.

Suggested books for readings:

1. **Biochemistry & Molecular Biology of Plants :** Bob B. Buchanan, Wilhelm Gruissem, and Russell L. Jones. 2000. ASPP publication
2. **Lehninger Principles of Biochemistry :** David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.
3. **Molecular Biology and Genomics:** Cornel Mulhardt. 2007. ELSEVIER
4. **Introduction to Genetic Analysis:** Griffiths, Wessler, Lewontin, Carroll. (Ninth Edition) 2008. W.H. Freeman and Company
5. **Plant Cell And Tissue Culture:** Indra K. Vasil and Trevor A. Thorpe. Kluwer

Academic Publishers Group (1994)

6. **Principles of Gene Manipulation and Genomics:** S.B. Primrose and R.M. Twyman.(Seventh edition) 2008. Blackwell Publishing
7. **Journals:** Annual Review of Plant Biology, Critical Reviews in Plant Science, Current Opinion in Plant Biology, Trends in Plant Science, Plant Physiology, Plant Cell, Annual Review of Plant molecular biology, Annual Review of Plant Physiology, Plant Molecular Biology

SEMESTER-IV

221 405: Practical: According to theoretical syllabus in special paper-I&II

Continuous evaluation	**50 Marks**
Final Practical Examination Viva	**25 Marks**
Dissertation Projects (Literature Review Works)	**50 Marks**
Seminar	**25 Marks**

	Total = 150 Marks

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