University of North Bengal
Department of Botany

CHOICE BASED CREDIT SYSTEM (CBCS) SYLLABUS FOR M.SC.
Duration: Two years (Four Semesters); Total marks 1600 [64 CREDITS]

Sem	Crs	Course	New Course Code	Course Type	Course Name		Marks	Full marks (Theory)	Full marks (Practical)	Full marks (Internal)	Total Final marks	Credit	Hours/ Week	Paper sequence
1	304	Botany	BOTA-CT-101	T	Group A	Microbiology-I	25	50		30	80	3.2	6	1
					Group B	Microbiology-II	25							
1	304		BOTA-CT-102	T	Group A	Mycology and Plant Pathology-I	25	50		30	80	3.2	6	2
					Group B	Mycology and Plant Pathology-II	25							
1	304		BOTA-CT-103	T	Group A	Taxonomy of Angiosperms-I	25	50		40	90	3.6	6	3
					Group B	Taxonomy of Angiosperms-II	25							
1	304		BOTA-CP-104	P	Microbiology				50		50	2	6	4
1	304		BOTA-CP-105	P	Mycology and Plant Pathology				50		50	2	6	5
1	304		BOTA-CP-106	P	Taxonomy of Angiosperms				50		50	2	6	6
			TOTAL MARKS & CREDITS IN THE SEMESTER 1								**400**	**16**	**36**	
2	304		BOTA-CT-107	T	Group A	Plant Physiology	25	50		30	80	3.2	6	7

					Group B	Plant Biochemistry	25							
2	304		BOTA-CT-108	T	Group A	Cytology and Genetics-I	25	50		30	80	3.2	6	8
					Group B	Cytology and Genetics-II	25							
2	304		BOTA-CT-109	T	Group A	Phycology and Bryology	25	50		40	90	3.6	6	9
					Group B	Pteridology, Gymnology, Palaeobotany	25							
2	304		BOTA-CP-110	P	Plant Physiology and Biochemistry				50		50	2	6	10
2	304		BOTA-CP-111	P	Cytology and Genetics				50		50	2	6	11
2	304		BOTA-CP-112	P	Phycology, Bryology, Pteridology, Gymnology and Palaeobotany				50		50	2	6	12
			TOTAL MARKS & CREDITS IN THE SEMESTER 2								**400**	**16**	**36**	
3	304		BOTA-CT-113	T	Group A	Plant Development	25	50		25	75	3	6	13
					Group B	Plant Metabolism	25							
3	304		BOTA-CT-114	T	Group A	Genetic Engineering	25	50		25	75	3	6	14
					Group B	Bioinformatics and Biostatistics	25							
3	304		BOTA-CT-115	T	Group A	Ecology	25	50		25	75	3	6	15
					Group B	Pharmacognosy	25							
3	304		BOTA-CT-116	T	*Elective Special Paper-I			50		25	75	3	6	16

3	304		BOTA-CP-117	P	Group A	Genetic Engineering and Bioinformatics	25		50		50	2	6	17
					Group B	Biostatistics	25							
3	304		BOTA-CP-118	P	Group A	Ecology	25		50		50	2	6	18
					Group B	Pharmacognosy	25							
			TOTAL MARKS & CREDITS IN THE SEMESTER 3								**400**	**16**	**36**	
4	304		BOTA-CT-119	T	Group A	Bioresource Utilization, Medicinal Plants and Natural History	25	50		30	80	3.2	6	19
					Group B	Techniques in Botany	25							
4	304		BOTA-CT-120	T	*Elective Special Paper-II			50		35	85	3.4	6	20
4	304		BOTA-CT-121	T	*Elective Special Paper-III			50		35	85	3.4	6	21
4	304		BOTA-CP-122	P	*Elective Special Paper Practical				100		100	4	12	22
4	304		BOTA-CP-123	P	Dissertation			50			50	2	6	23
			TOTAL MARKS & CREDITS IN THE SEMESTER 4								**400**	**16**	**36**	

*** ELECTIVE SPECIAL PAPERS**
(THEORY PAPERS: **BOTA-CT-116**, **BOTA-CT-120**, **BOTA-CT-121**; PRACTICAL PAPER: **BOTA-CP-122**)

LIST OF ELECTIVE SPECIAL PAPERS (ANY **ONE COMBINATION** TO BE SELECTED FOR THE ELECTIVE SPECIAL PAPERS IN SEMESTER 3 & 4)

I. Genetics and Bioinformatics
II. Microbiology
III. Molecular Plant Pathology and Fungal Biotechnology
IV. Plant Biochemistry
V. Plant Genetics and Molecular Breeding
VI. Plant Physiology and Pharmacognosy
VII. Pteridology, Palaeobotany and Palynology
VIII. Taxonomy of Angiosperms and Biosystematics

INTERNAL ASSESSMENT
Class Tests, Assignments, Seminars, Field Studies, Scientific Outreach, Attendance etc.

PREAMBLE

The Department of Botany of University of North Bengal was initiated in the summer of 1984. Since then the Department flourished tremendously with tireless efforts of faculties, staff and students. The Department has marked its golden presence by its remarkable achievements in shaping the scientific and academic pursuit of Sub-Himalayan West Bengal, Sikkim and neighbouring countries like Nepal, Bhutan and Bangladesh. Though, being a University situated in a remote location with limited resources and infrastructure, our University as well as the Department is second to none when it comes to producing quality students, researchers and scientists.

The voyage started off in the year 1982 with the decision of the University authority to have two new departments namely Botany and Zoology under the Centre for Life Sciences, the then a unit exclusively for R&D. The Department has received Special assistance program (SAP-DRS) for three phases (2002-2007, 2007-2012 and 2013-2018) as well as DST-FIST assistance in 2003. With the support from the Department of Environment and Forests, Govt. of India, a Botanic garden has been set up while with the financial support from the Department of Biotechnology, Ministry of Science and Technology, Govt. of India, Infrastructural facilities including Immuno-Phytopathology Laboratory, Tea Germplasm Bank, Rice Germplasm Bank, Antisera Reserves for Plant pathogens, Mushroom Production Unit have been established. With the financial support of DST, West Bengal and National Medicinal Plants Board a beautiful garden of Medicinal Plants has been developed in this campus. This year the University has uplifted this as a Centre for Conservation and Utilization of Medicinal and Aromatic Plants. The Department has been rendering bioinformatics facility in this University with the support from DBT, Govt. of India.

MASTER OF SCIENCE IN BOTANY

PROGRAMME OBJECTIVES:

The Master of Science in Botany Programme is framed to inculcate the students with basic and advanced knowledge in plant sciences. Students would be taught with different aspects of the subject comprising of a well thought out combinations of core and elective papers which includes the developments in modern biology and interdisciplinary sciences. Students would be engaged in field trips so as to enhance their practical experiences with the diversity of plant forms and also the impact of ecological variations on the same. Students would be exposed to hands on experiences of performing different experiments and usage of different instruments to develop their overall expertise and prepare them for the future.

PROGRAMME SPECIFIC OUTCOMES:

- Students after completing this programme will have a complete knowledge about the different branches of the subject including the background and history of the development of the subject, basics and advances of the subject.
- Students would be able to distinguish the different life forms of plants and will have a detailed understanding of the recent systems of classification and techniques of identifying the plants.
- Students would be able to build up on the foundations of the topics including physiology, biochemistry, microbiology, genetics, molecular biology, genetic engineering, plant development, pharmacognosy and so on and would be able to explore the further advances in the topics on their own.
- Students would be able to utilize their experience of executing dissertation work and using different tools and techniques in their future research and development assignments.

SEMESTER I

COURSE TYPE: THEORY (T)

COURSE CODE: BOTA-CT-101		
Credit: 3.2	**Full Marks: 80 [50 (T) +30 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to teach the students with the basics and advances of Microbiology. The course is divided in to two groups of equal weightage. At first, the diversity, growth and nutrition and metabolism of microorganisms will be dealt with. After that the different aspects of viruses and plant-microbe interaction will be undertaken.

COURSE LEARNING OUTCOMES:

- Students will understand the diversity of microbial life forms and the recent system of their classification.
- Students will gain complete knowledge regarding the morphological and anatomical features of bacteria and viruses, different metabolic pathways associated with bacteria, concepts of the nutritional requirements and growth patterns and also learn about the basics and advances in bacterial genetics.
- Students will be able to understand the concept of plant-microbe interaction, the importance and mechanism of it.
- Students will also learn about the importance of microorganisms in human welfare right from their usage in food and beverages to their utility in pharmaceutics and biotechnology.

COURSE CONTENTS

GROUP A: MICROBIOLOGY-I

Marks: 25 Total lecture hours: 32

1. Diversity: Classification and survey of microorganisms; Microbial phylogeny as revealed by rRNA sequencing, Classification of bacteria - Bergey's manual of systematic bacteriology – outline only.
2. Morphology and anatomy of cells: Morphology; Cell surfaces (glycocalyx, cell wall, flagella, and pili) and their role; Plasma membrane (bacterial and archaeal); Prokaryotic chromosome: Ribosome; Endospores.
3. Metabolism: Photosynthesis (anoxygenic and oxygenic); Chemosynthesis; Fermentation (alcoholic, Entner-Doudoroff pathway; lactic acid – homo and hetero, propionic acid, mixed acid, butanediol and butanol; Stickland reaction); Respiration (anaerobic and aerobic).
4. Growth and nutrition: Measurements of growth; Generation time; Continuous culture; Synchronized growth; Diauxy; Environmental factors influencing growth, Organic growth factors; Inorganic requirements; Physical and ionic requirements.
5. Bacterial Genetics and Recombination: Organisation and structure of bacterial genome, Replication of prokaryotic chromosomes; Molecular basis of mutation; Isolation of mutants; Modes of recombination (transformation, transduction, and conjugation).

GROUP B: MICROBIOLOGY-II

Marks: 25 Total lecture hours: 32

1. Virology: Morphological classes of viruses; Structure of Adenovirus, Tobacco mosaic virus, and coliphage T_4.
2. Plant–microbe interactions: Mycorrhizae, Nitrogen fixing associations between rhizobia and legumes, cyanobacteria - plant symbiosis. Plant growth promoting rhizobacteria.
3. Biological nitrogen fixation: Biology and biochemistry; Rhizobial association with plant roots and root nodulation; Commercial production of rhizobia.
4. Commercial application of Microbes: Use of microbes in food industry, Use of microbes in agriculture, Use of microbes in pharmaceutical industry, Use of microbes in biotechnology.

COURSE CODE: BOTA-CT-102		
Credit: 3.2	**Full Marks: 80 [50 (T) +30 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to teach basic, economic and molecular aspects of fungi, host pathogen interactions and control measures will also be taught. Diseases of crop plants and their diagnosis will be taught with recent advancements. Information about immunological and molecular diagnostics will also be given to the students.

COURSE LEARNING OUTCOMES:

- Students will understand the role of fungi in different sector of life with special reference to agriculture.
- Students will learn about different plant-pathogen interactions, their diagnosis and control.
- Students will learn about sustainable agriculture.
- Students will also learn about recent molecular developments of plant-microbe interaction.

COURSE CONTENTS

GROUP A: MYCOLOGY AND PLANT PATHOLOGY-I

Marks: 25 Total lecture hours: 32

1. Economic importance of Fungi (General account), Fungi as pathogen and biocontrol agents (general account), Human diseases of Fungi.
2. Ultrastructure of fungal cell; Cell wall composition and biogenesis.
3. Protoplast isolation, fusion, regeneration and reversion.
4. Translocation in mycelia.
5. Somatic recombination in fungi.
6. Molecular genetic analysis of fungi. Extra chromosomal and transposable genetic elements in fungi.
7. Cell cycle control points in yeast.
8. Protein secretion in yeast: Secretion pathway; directed secretion; morphology of secretary pathway; processing, modification and folding of secretary proteins.
9. Fungi in industry & medicine: Antibiotics- Penicillin; Organic acids – Citric acid; Plant growth regulator- Gibberellin, alcohol and Fungal enzymes (general account)
10. Fungal toxins: Host non selective toxins- cercosporin (Mode of action); Host specific toxins- structure, mode of action and concept of V_b gene.
11. Mycotoxins- aflatoxin biosynthetic pathway with enzymatic and genetic informations.

GROUP B: MYCOLOGY AND PLANT PATHOLOGY-II

Marks: 25 Total lecture hours: 32

1. Penetration, infection, invasion of host tissue, relationship between pathogen and host factor(s), structural and biochemical defense mechanism in plant.
2. Mycorrhizae: interaction; Specific recognition in mycorrhizal association; Application as biofertilizer and bioprotector in forestry and agriculture.
3. Structural and chemical decay of wood by decaying microorganisms.
4. Details studies of fungal diseases: Damping off, powdery mildew, downy mildew, smut, bunt, rust, wilt, root rot, leaf spots, leaf blight and gall of economically important crops.
5. Bacterial diseases: bacterial leaf blight of rice, bacterial wilt of potato, bacterial canker of tomato, crown gall of rose.
6. Nematode disease: General features; Mechanism of nematode injury to plants; Factors affecting survival and parasitism of nematodes; Molecular approach in the management of virulence genes in potato cyst nematodes.
7. Virus disease: Symptoms, carrier, transmission, interaction of virus and host; role of nucleic acid in virus infection; establishment and development of virus infection; control strategies.
8. Plant disease control: chemical control and biological control of phytopathogens, insect pest and weeds. Application of avirulence genes in control of plant pathogens.

COURSE CODE: BOTA-CT-103		
Credit: 3.6	**Full Marks: 90 [50 (T) +40 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to enhance the understanding of the students about the diversity and conservation of Flowering plants, their Description, Identification, Nomenclature and their classifications including recent advances in the field. The course also enhances the knowledge about Ethnobotany, Biodiversity

conservation, Botanical gardens and Medicinal plants.

COURSE LEARNING OUTCOMES:

- Students will understand differences between Plant taxonomy and systematic; components, importance and data sources in systematics.
- Students will understand the principle of nomenclature, history and recent development in classifications.
- Students will understand the concept of phenetics and cladistics.
- Students will acquire knowledge of different methods of collecting and preserving plants, biodiversity conservation and ethnobotany.

COURSE CONTENTS

GROUP A: TAXONOMY OF ANGIOSPERMS-I

Marks: 25 Total lecture hours: 32

1. International Code of Nomenclature (ICN) - Basic Principles. Major Rules: (a) Type concept; (b) Principle of priority; (c) Valid & effective publication; (d) Starting points of Nomenclature, (e) Limitations to the principle of priority.
2. Character Concept and artificial keys.
3. Source of data for Systematics: (a) Anatomy, (b) Cytology, (c) Embryology, (d) Palynology, (e) Phytochemistry, (f) Genome Analysis.
4. The Origin of Species.
5. Taxonomic literature, Herbaria and herbarium techniques, Molecular Techniques, Computer and Geographic Information System (GIS).
6. Botanic Gardens.

GROUP B: TAXONOMY OF ANGIOSPERMS-II

Marks: 25 Total lecture hours: 32

1. Major classification - its need, philosophy and brief history.
2. Phenetic versus cladistics; APG System.
3. Characterization and phylogeny of Basal Angiosperms and Magnoliids, Basal monocots, Petaloid monocots, Commelinids, eudicots, Caryophyllids, Rosids, Asterids.
4. Biodiversity - importance and conservation; Biodiversity conservation Hotspots, IUCN guide lines; invasions & introductions, endemism.
5. Ethnobotany: concept, need, methods of survey; sacred groves.

COURSE TYPE: PRACTICAL (P)

COURSE CODE: BOTA-CP-104

Credit: 2 **Full Marks: 50** **Total working hours: 96**

MICROBIOLOGY

1. Study of microscope.
2. Basic principles of sterilization, disinfection, safety in microbiological laboratory.

3. Preparation of media, identification and culturing of various microorganisms (streak-plate, pour-plate, and spread-plate techniques).
4. Isolation and enumeration of viable microorganisms from soil by serial dilution-agar plate method.
5. Differential Staining (Gram- staining and endospore) and study of morphology of prokaryotic cells.
6. Study of bacterial growth using turbidimetric method.
7. Isolation and study of rhizobia from root nodules.
8. Antibiotics sensitivity test using paper disc method.

COURSE CODE: BOTA-CP-105		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

MYCOLOGY AND PLANT PATHOLOGY

1. Identification of fungal cultures: *Colletotrichum, Curvularia, Alternaria, Pestalotiopsis, Trichoderma, Fusarium, Dreschlera.*
2. Study of lifecycles of some selected fungi from charts/ slides etc.
3. Study of mycoflora of air/soil.
4. Preparation of media, Isolation of pathogen (Fungi and Bacteria) from diseased plant material.
5. Study of Koch's postulates and pathogenecity test in whole plants/cut shoots/ leaves.
6. Identification of fungi by molecular technique (by ITS region amplification and BLAST analysis) -Demonstration from an Identified organism.
7. Detection of viral pathogen by molecular technique.
8. Bioassay of antifungal compounds/fungicides by agar well/disc method.
9. Determination of ED_{50} value of fungicides by spore germination method.
10. Thin layer chromatography and bioassay of antifungal compounds.
11. Histopathological studies of fungal diseases of economically important crops.
12. Artificial inoculation of plants with pathogen(s) and disease assessment.
13. Comparison of soluble protein content between healthy and artificially inoculated plants.
14. Comparison of total and orthodihydroxy phenol content between healthy and artificially inoculated plants.
15. Extraction and assay of Phenylalanine ammonia lyase activity in plants following infection.
16. Extraction and assay of peroxidase activity in plants following infection.

COURSE CODE: BOTA-CP-106		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

TAXONOMY OF ANGIOSPERMS

1. Description and identification of some representative plants from locally available families.
2. Locating the key-characters at generic and specific levels.
3. Temporary preparation of pollen slides and study of exine morphology and aperture structure in a few simple palynomorphs.
4. Preparation of artificial keys.
5. Determination of similarity coefficients of some randomly selected plants.
6. Embryo structure of some common angiospermic plants.
7. Training in using Floras and Herbaria.

8. Field trip within and near-by areas; compilation of field notes and preparation of herbarium sheets of commonly available plants.

SEMESTER II

COURSE TYPE: THEORY (T)

COURSE CODE: BOTA-CT-107		
Credit: 3.2	**Full Marks: 80 [50 (T) +30 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to teach the students with the basics and advances of Plant Physiology and Biochemistry. The course is divided in to two groups of equal weightage. This course aims to enhance the understanding of the students about importance of water in plant life, assimilate distribution and partitioning, perception of light and their signalling mechanisms along with physiology of plant growth regulators in the first group. In the second group, the students will learn about the basic and modern concepts of biomolecules including proteins, carbohydrates, lipids and enzymes. Also, thermodynamic principles and physical forces governing cellular life will be taught about.

COURSE LEARNING OUTCOMES:

- Students will learn about properties of water, their role in plant life, water potential and measuring system, transport of water through vascular tissues, possible challenges during adverse condition and their mitigation measures.
- Students will be taught about the concept photosensory biology, mechanism of light mediated physiological control of stomatal regulation, response in dark and their mechanism and their overall coordinated cascades.
- During this course students will learn about transport of assimilates from leaf to root, possible theories involved, crisis during pathogenic injury and the process of partitioning in different tissues.
- Students will also gain the knowledge about plant growth regulators, structure function relationship, physiology and homeostasis and control of signalling by degradation of repressors through ubiquitin ligation.
- Students will gain knowledge on the structural and biochemical properties of different macromolecules and also on cellular energetics.

COURSE CONTENTS

GROUP A: PLANT PHYSIOLOGY

Marks: 25 Total lecture hours: 32

1. Water balance in plants: Structure and chemical nature of water; Thermal, adhesive and cohesive properties; Diffusion, Osmosis and Bulk flow; Water Potential: physiological role; Measuring water potential; Aquaporin channels; Water absorption by root; Tracheid and Vessel anatomy; Transport through Xylem: Cohesion-tension theory; Cavitation and Embolism; Stomatal control of water movement.

2. Translocation in the phloem: Pathways of translocation; Phloem anatomy; Sealing process of damaged sieve elements; Pattern of translocation: source to sink; Phloem sap composition; Pressure-Flow model of Phloem transport; Apoplastic and symplastic phloem loading; Polymer Trapping Model; Phloem unloading; Allocation and partitioning.
3. Photosensory biology of plants: Photochemical and biochemical properties of phytochrome; Phytochrome induced physiological responses; Classification and properties of light responses; Structure and function of phytochrome protein; Phytochrome signaling pathways; Photophysiology of Blue Light responses; Blue light photoreceptors; Molecular mechanism of light stimulated stomatal opening.
4. Plant growth regulators: Concept of hormones and plant growth regulators; Structure, biosynthesis and metabolism of auxin, gibberellins and cytokinin; Physiological role of plant growth regulators; Signaling and molecular mode of action of auxin, gibberellins and cytokinin.

GROUP B: PLANT BIOCHEMISTRY

Marks: 25 Total lecture hours: 32

1. Aqueous solutions and Bioenergetics: Properties of water; acids, bases and buffers; pH, indicator; thermodynamic principles; concept of free energy and chemical equillibrium; role of ATP and ATP cycle.
2. Carbohydrates: Structure, classification, properties and function; plant storage carbohydrates; cell wall- structure & function; glycoproteins and proteoglycans.
3. Lipids and membranes: Structure, classification, properties and function; types and function of membrane lipids; membrane transport proteins: types and mechanism; primary and secondary active transport.
4. Proteins: Amino acid components and structural features; primary and higher order structures; Ramachandran plot; motif, fold and domain; polypeptide sequencing and purification strategies.
5. Enzymology: Enzyme kinetics- Michaelis-Menten and Lineweaver Burke plot; enzyme inhibitions and their kinetics; collision & transition state theories; random and ordered Bi-Bi mechanisms, Ping Pong reaction; role of coenzymes and cofactors.

COURSE CODE: BOTA-CT-108		
Credit: 3.2	**Full Marks: 80 [50 (T) +30 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to teach the students with the basics and advances of Cytology and Genetics which is divided in to two groups of equal weightage. Genetics is the subject directly linked to societal growth and development including quality of life. The course aims to provide basic information about the cell which is a basic unit of life, cell theory, evolution of cell, Mendelian Genetics. The course provides insights in to modern day genetics.

COURSE LEARNING OUTCOMES:

- Students will gain knowledge about cell theory and evolution.
- Students will learn the concepts of Mendelian Genetics and the recent views on the same.
- Students will gain knowledge on basics of plant breeding, hybridisation techniques and marker-assisted selection.

- ❖ Students will be able to understand the concepts of transcription, translation, mutation and gene regulation.

COURSE CONTENTS

GROUP A: CYTOLOGY AND GENETICS-I

Marks: 25 Total lecture hours: 32

1. Mendel's principles of inheritance and extension of Mendel's law, chromosome theory of heredity; Linkage, crossing over and recombination at the molecular level, chromosome mapping, Evolving concept of gene-an overview.
2. Cytological variation- an overview, molecular basis of chromosome pairing in mitosis and meiosis; Circuits of lytic cycle and lysogeny in bacteriophage lambda.
3. Structure of DNA and chromosome, DNA polymerases-DNA synthesis, unique aspects of eukaryotic chromosome replication; gene expression and chromosome organization; Dosage compensation and genetic imprinting, PTGS, RNA interference.
4. Genetics and Plant breeding- Basics of plant breeding- principles and methods. Hybridization, genetic analysis of complex traits, prediction-broad sense and narrow sense heritability, QTL mapping and analysis; Marker assisted selection in Rice breeding.

GROUP B: CYTOLOGY AND GENETICS-II

Marks: 25 Total lecture hours: 32

1. Mutation at morphological, biochemical and molecular level; nucleic acid and their structure; synthesis, modification and repair of DNA; DNA fingerprinting- RFLP, AFLP, RAPD.
2. Transcription in prokaryotes and eukaryotes; RNA processing; translation in prokaryotes and eukaryotes; Operon circuits; Lac operon-Tryptophan operon, attenuation and antitermination; the genetic code and its evolution; codon-tRNA interaction, protein synthesis and evolution of protein synthesis.
3. Transposons and retro-elements, Sex-linked, sex-limited and sex-influenced traits, sex determination, sex differentiation; maternal effects and cytoplasmic inheritance
4. Regulation of eukaryotic gene regulation- an overview, ways of regulation of gene expression.

COURSE CODE: BOTA-CT-109		
Credit: 3.6	**Full Marks: 90 [50 (T) +40 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to give a detailed knowledge about the ancestral plants and their origin, evolutionary trends and comparative analysis. This course also deals with anatomical and morphological details which can be studied to understand the basic interrelationship among different groups. The course is divided in to two groups of equal weightage. The first group includes the structural diversity and other features of algae and bryophytes. The second group includes the details of pteridophytes, gymnosperms and fossil plants.

COURSE LEARNING OUTCOMES:

- Students will understand the structural diversity of algae, bryophytes, pteridophytes, gymnosperms; classification systems, morphological and anatomical features and evolution of the different life forms.
- Students will learn the structural details and life history of different fossil plants.
- Students will also gain knowledge regarding the applications of the lower group of plants.

COURSE CONTENTS

GROUP A: PHYCOLOGY AND BRYOLOGY

Marks: 25 Total lecture hours: 32

Phycology

1. General overview Basic charateristics features and modern system of classification.
2. Evolution of Algae and range of thallus structure among different groups.
3. General features of the division Cyanophyta. Ultrastructure of cell and Heterocyst, Glaucophyta-General characteristics and primitive features, phylogenetic significance. Dinophyta- Cell structure; Heterotrophic nutrition; Red-tides. Chlorophyta -Ultra structure of flagella; classification and phylogeny. Bacillariophyta - Classification; Ultra structure and developmental patterns of Diatom frustules.

Bryology

1. General habit, habitat, distribution, of Bryophytes.
2. Recent trend for classification of Bryophytes and outline on a recent classification system of (liverworts, hornworts and mosses).
3. Comparative morphology and anatomy of Liverwort, Hornwort and Mosses and their evolutionary significance.
4. Role of Bryophytes in ecology, Desiccation tolerant, succession bio-indicator and as phytoremediator.

GROUP B: PTERIDOLOGY, GYMNOLOGY AND PALAEOBOTANY

Marks: 25 Total lecture hours: 32

Pteridology

1. Introduction: A general account and outline of recent system of classification of Pteridophytes; distribution of extant and extinct groups of Pteridophytes in time and space.
2. Evolutionary trends and affinities in the members of Zosterophyllopsida, Trimerophytopsida, Lycopsida, Sphenopsida and Filicopsida.
3. Types of spore, sporangium development and germination process of spores of Pteridophyte and patterns of gametophytes development and mating system in fern.

Gymnology and Palaeobotany

1. General characters and different systematic treatments of Gymnosprems as proposed by Sporne (1974) and Bhatnagar and Alok Moitra (1996); Pteridosperms and progymnosprems and their evolutionary significance; Brief account of extinct Cycadales, Coniferales with emphasis on evolutionary aspects.
2. Comparative account of sporophytes and gametophytes of Cycadales, Coniferales, Ginkgoales and Gnetales.
3. Aims and objectives of Palaeobotany; Geological time scale and different types of fossil flora in India; Dating techniques of fossils.

4. Pollen and spore morphology (NPC classification); exine stratification, structure and sculpture of sporoderm and their significance; Branches of Palynology - Melittopalynology, Aeropalynology, Forensic palynology and Palaeopalynology and their significance.

COURSE TYPE: PRACTICAL (P)

COURSE CODE: BOTA-CP-110		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

PLANT PHYSIOLOGY AND BIOCHEMISTRY

1. Determination of amylase activity of monocot seeds in different stages of germination.
2. Assay of Catalase activity of fresh and preserved potato tubers.
3. Study of mobilization of starch during seed germination by embryo.
4. Effect of different solutes and temperature on membrane permeability.
5. Determination of water potential of plant tissue.
6. Quantitative estimation of Indole-3-Acetic Acid by Salkowski Reagent.
7. Preparation of buffers, solutions and dilutions.
8. Extraction of carbohydrates from plant materials and estimation of total and reducing sugars.
9. Determination of acid value and/or iodine number of fat.
10. Extraction of proteins from plant materials and estimation by Lowry/ Bradford method.
11. Extraction of chloroplast pigments and quantitative estimation of chlorophylls, carotenoids and anthocyanins.
12. Enzyme kinetics - effect of substrate concentration and temperature on enzyme activity.

COURSE CODE: BOTA-CP-111		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

CYTOLOGY AND GENETICS

1. Orcein and Feulgen staining of metaphase plates; preparation of karyotype and IdIogram.
2. Linear differentiation of chromosomes through G-banding, C-banding and Q-banding.
3. Induction of polyploidy using colchicine; different methods of application of colchicine
4. Study of Meiotic chromosome complements.
5. Isolation of genomic and plasmid DNA.
6. Restriction digestion and electrophoresis.
7. PCR and RAPD analysis.
8. Probability and chi-square test for genetic analyses for goodness of fit.
9. Human genetics study of simple human traits.
10. Tissue culture - basic techniques and regeneration of plantlets.

COURSE CODE: BOTA-CP-112		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

PHYCOLOGY, BRYOLOGY, PTERIDOLOGY, GYMNOLOGY, PALAEOBOTANY AND PALYNOLOGY

1. Morphological study of representative members of Cyanophyceae, Chlorophyceae, Phaeophyceae, Bacillariophyceae, Rhodophyceae.
2. Study of reproductive members of different groups of Bryophytes: Hepaticopsia, Anthocerotopsida, Bryopsida.
3. Study of external and internal morphology of vegetative and reproductive structure (spore types and soral anatomy etc.) of species of: *Drynaria*, *Lygodium*, *Dicranopteris*, *Nephrolepis*, *Asplenium*, *Blechnum*, *Adiantum*, *Christella*, *Microsorum*, and *Salvinia*.
4. External morphological features of the following taxa: *Psilotum*/*Tmesipteris*, *Isoetes coromandelina*, *Ophioglossum*, *Marattia*, *Ceratopteris*, *Dryopteris*, *Cheilanthes*, *Woodwardia* and *Onychium*.
5. Study of the external morphology of the following taxa: *Zamia*, *Ginkgo*, *Cedrus*, *Araucaria*, *Thuja*, *Cupressus*, *Cryptomeria*, *Gnetum* and *Ephedra*.
6. Study of general habit, external and internal morphology leaf and wood anatomy with special reference to male and female reproductive structure: *Cycas*, *Pinus*, *Cryptomeria*, *Thuja*, *Araucaria*.
7. Study of different types of fossils.
8. Acetolysis method (demonstration); study of morphology of modern spores and pollen grains.

SEMESTER III

COURSE TYPE: THEORY (T)

COURSE CODE: BOTA-CT-113		
Credit: 3	**Full Marks: 75 [50 (T) +25 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

Plants are adapted with complex system of development characterized with precisely programmed polar growth. In order to conceptualize this, one should inspect carefully the various stages of organ development from embryogenesis. This course is designed for making the students acquainted with gene expression at different stages and their interaction along with fundamental histological perspectives. In the second group, the course aims to teach the students with in depth knowledge of the major metabolic pathways in plants.

COURSE LEARNING OUTCOMES:

- Students will acquire knowledge about embryogenesis from zygotic development and functional perspectives of different histogens.
- Students will also know about root, shoot and leaf development and the key molecular mechanisms involved during development.
- During this course students will learn about transformation of shoot apical meristem into inflorescence and floral meristem and the involvement of hormone florigen during juvenile to adult transition.

- This course will also highlight students about floral organogenesis and their possible molecular mechanisms along with distortion of development during gene mutation.
- Students will have complete understanding of the two major cellular processes *viz.* photosynthesis and respiration and the pathways associated with them.
- Students will gain knowledge regarding the lipids as a source of energy and also how they are synthesized.
- Students will also get aware of nucleotide and protein biosynthesis and amino acid families and their biosynthesis.

COURSE CONTENTS

GROUP A: PLANT DEVELOPMENT

Marks: 25 Total lecture hours: 32

1. Embryogenesis: Structure of embryo sac; Different stages of *Arabidopsis* embryogenesis; Rice embryogenesis; Vegetative and reproductive development; Origin of polarity; Development of body plan; Formation of tissue system; Position dependent signaling during embryogenesis; Development of endosperm.
2. Plant hormones as morphogen: Chemiosmotic model for polar auxin transport; Mechanism of auxin induced cell elongation; Control of phototropism and gravitropism; Developmental effects of auxin; Gibberellin induced stem growth and transition from juvenile to adult development; Cytokinin induced cell division in root and shoot; Auxin cytokinin ratio regulating morphogenesis in cultured tissues; Apical dominance and lateral bud growth; Effect of Brassinosteroids on cell division, root growth and vascular differentiation.
3. Shoot and root apical meristem development: Organization of root and shoot apex; Genes controlling apical-basal and radial patterning; Sequence of gene expression during shoot apex development; Maintenance of stem cell population by transcriptional feedback loop; Developmental zones of root tip; Genes involved in organogenesis of root tip
4. Leaves and lateral organ formation: Control of leaf initiation; Dorsiventral and isobilateral leaf anatomy; Polarity of leaf development; Spatial regulation of gene expression; Micro-RNA regulating leaf architecture; Molecular control of stomatal development.
5. Control of flowering: Photoperiodism and control of Florigen; Critical day length; Circadian clock; Molecular mechanism of phase change and floral evocation; Biochemical signaling under long and short day; Vernalization; Genes controlling floral meristem identity; Homeotic control of floral organ identity- ABC and ABCD Model.

GROUP B: PLANT METABOLISM

Marks: 25 Total lecture hours: 32

1. Photochemistry and photosynthesis: General concepts; photosynthetic pigments and light harvesting complexes; photo-oxidation of water; mechanisms of electron and proton transport; Benson-Calvin cycle; CO_2 concentrating mechanisms.
2. Respiration: Overview of plant respiration; glycolysis; TCA cycle, electron tansport systems and ATP synthesis; alternative oxidase system.
3. Lipid metabolism: Fatty acid biosynthesis and breakdown; synthesis of storage and membrane lipids.
4. Nucleotide and protein biosynthesis: Purine and pyrimidine biosynthesis, de novo and salvage pathways; regulation and degradation; transcription, translation and post-translational modifications.

5. Amino acid biosynthesis: Ketoglutarate and oxaloacetate families.

COURSE CODE: BOTA-CT-114		
Credit: 3	**Full Marks: 75 [50 (T) +25 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

Students will learn about the biological species and how the species barrier has been overcome through gene transfer. By studying the subject of genetic engineering they will become aware about this mechanism of gene transfer without considering the species barrier. Bacterial gene can be transfer to plant or *vice versa*. Students also can know about the mechanism of transgenic plant development for GM-Crop production. Students will also learn about the fundamentals of bioinformatics and biostatistics.

COURSE LEARNING OUTCOMES:

- Students will acquire knowledge about the tools and techniques of recombinant DNA technology.
- Students will learn about the development of transgenics, their applications and ethical issues related to their use.
- Students will be exposed to the concept of gene silencing and gene knockouts.
- Students will gain knowledge regarding the concept and different tools used in bioinformatics, about the different DNA and protein databases.
- Students will be learning the concepts to use different biostatistics tools and methods in data analysis.

COURSE CONTENTS

GROUP A: GENETIC ENGINEERING

Marks: 25 Total lecture hours: 32

1. Recombinant DNA Technology: Overview and fundamental techniques of rDNA technology; Restriction enzymes; DNA ligase, Cohesive and blunt end ligation. Hybridization techniques: Northern, Southern, Western and Colony hybridization.
2. Basic biology of plasmid and phage vectors: Plasmids; Bacteriophages; M13 mp vectors;pBR322, pUC19 and Bluescript vectors, Phagemids; Lambda vectors; Cosmids; YACs; BACs; Expression vectors; pMal; GST; pET; Protein purification; His-tag; GST-tag; MBP-tag. Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors.
3. Gene cloning strategies: Introduction; principles of gene cloning and methods; insertion of foreign DNA into host cells; transformation; cDNA and genomic libraries; expression cloning; library screening, expression libraries; procedure of cell based cloning and PCR based cloning.
4. Gene transfer to plants: Overview, Agrobacterium mediated gene transfer and viral vectors; selectable marker and reporter genes; direct gene transfer to plant cell. Control of transgene expression in plants; transgene analysis- silencing and targeting.
5. Molecular farming and Transgenic: Overview, transgenic plants as bioreactors. Advantages of plant made pharmaceuticals.
6. Gene silencing techniques: Introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts.

GROUP B: BIOINFORMATICS AND BIOSTATISTICS

Marks: 25 Total lecture hours: 32

1. Bioinformatics and its application in biological research; Biological databases – Primary, Secondary databases; Structural database- SCOP, CATH, PDB; Resources- NCBI, ExPASY,EBI.
2. Substitution Matrix – PAM, BLOSUM, PSSM; Algorithm behind searching tools: BLAST, PSI-BLAST, PHI-BLAST, Hidden Markov Model.
3. Dynamic programming algorithm and its use in sequence alignment. Multiple and Pairwise alignment. Basic ideas on multiple sequence alignment editors – Clustal W, Bioedit.
4. Phylogeny: Rooted, Unrooted tree. Tree generation methods – UPGMA, NJ, Maximum parsimony. Bootstrapping and its importance; Homology modeling, Molecular dynamics, Monte Carlo simulation.
5. Sampling and sample designs: Classification and tabulation of data; Diagrammatic and graphic presentation; Measures of dispersion: Variance, Mean deviation, Standard deviation.
6. Correlation and regression analysis; Binomial and poisson distribution; Tests of hypothesis; Analysis of variance (Anova)- Bivariate & multivariate.

COURSE CODE: BOTA-CT-115		
Credit: 3	**Full Marks: 75 [50 (T) +25 (IA)]**	**Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to familiarize the students with basic principles of origin of life, concept of evolution, genetic polymorphism etc. The students will be taught about structure and function of ecosystem, population dynamics, biological diversity and present day global environmental problems. The students will gain understanding of various biomes of the world and their conservation strategies. For several years, different plant parts and their extracted compounds were utilized by mankind for therapeutic purposes. The therapeutic potential of plants is determined by the presence of secondary metabolites in specific plant species. This course is designed to provide information about ethnomedicine, adulteration and quality control of herbal drugs and exploring tools about enormous diversity of secondary metabolites present in plant system.

COURSE LEARNING OUTCOMES:

- Students will learn the concept of molecular evolution and Hardy-weinberg genetic equilibrium.
- Students will get detailed study of interaction of different population, community and ecosystems and their role in ecosystem
- Students will learn the applications of ecological concept for benefit to different life forms.
- Students will acquire knowledge about historical perspectives of conceptual development of ethnomedicine.
- Students will learn about threats of possible drug adulteration and their scientific methods of measurement.
- Students will be acquainted with vast array of secondary metabolites in plants, their biosynthetic origin, chemical nature and bioactivity.
- Students will have appropriate understanding about the hallucinogenic drugs extracted from psychoactive plants and their bioactive components responsible for drug addiction.
- This course will also highlight students about floral organogenesis and their possible molecular mechanisms along with distortion of development during gene mutation.

COURSE CONTENTS

GROUP A: ECOLOGY

Marks: 25 Total lecture hours: 32

1. Origin of life (including aspects of prebiotic environment and molecular evolution), Concepts of evolution, Theories of organic evolution, Mechanisms of speciation and extinctions; Hardy-weinberg genetic equilibrium, genetic polymorphism and selection; Origin and evolution of economically important microbes, plants and animals.
2. Concepts and dynamics of ecosystem, components, food chain and energy flow, productivity and biogeochemical cycles; Types of ecosystem: Grassland and Savannas, Shrubland and Deserts, Tundra and, Taiga. Temperate forests, Tropical forests, Lakes and Ponds, Freshwater wetlands, Streams and Rivers, Oceans, Estuarine and Mangrove.
3. Population ecology (Basic characteristics with examples, life table, survivorshipcurves, growth curves) and biological control; Community structure and organization; Environmental pollution; Sustainable development; Economic importance of microbes, plants and animals.
4. Interactions between environment and biota; Concept of habitat and ecological niches; Limiting factor; Energy flow, food chain, food web and trophic levels; Ecological pyramids and recycling, biotic community-concept, structure, dominance, fluctuation, succession, N, P, C and S cycles in nature.
5. Ecosystem dynamics and management; Stability and complexity of ecosystems; Environmental impact assessment, Principles of conservation; conservation strategies; cryopreservation, Sustainable development. Ethical issues related to new-crops and introduction of transgenics. Climate change.

GROUP B: PHARMACOGNOSY

Marks: 25 Total lecture hours: 32

1. Pharmacognosy: Ethnic and modern concepts; Interdisciplinary spectrum of Pharmacognosy; History of Pharmacognosy: Egyptian, Babylonian, Ayurveda, Unani and Siddha Medication; Herbalism and Phytotherapy; Drugs and technical products; Pharmacopoeias; Preparation of herbal drugs for commercial market.
2. Adulteration of herbal drugs: Concept; Methods of Adulteration; Types of Adulteration; Disadvantages of Adulteration; Measures of Adulterants: Morphological, Microscopic, Chemical, Physical, Biological and Analytical methods.
3. Methods of plant analysis: Extraction and purification of natural products; Chromatographic study of drugs; Spectroscopic techniques; Methods of identification and analysis of results; Applications of phytochemical analysis.
4. Secondary metabolites: Characteristic features of secondary metabolites of plant origin; Basic metabolic pathways and origin of secondary metabolites; Structure and biological significance of terpenes, phenolic and nitrogen-containing compounds.
5. Drugs and consciousness: Psychoactive Drugs and physiology of brain; Drug dependence and addiction; Effect of Drugs; Depressants and Opioids; Stimulants; Hallucinogens- Marijuana; Psychoactive plants, bioactive constituents and therapeutic properties.

COURSE CODE: BOTA-CT-116		
Credit: 3	**Full Marks: 75 [50 (T) +25 (IA)]**	**Total lecture hours: 64**

*ELECTIVE SPECIAL PAPERS

Elective special papers will be provided as a choice to the students in both Semester-III and Semester-IV. In Semester-III, there will be only one theoretical paper "Elective Special Paper I (BOTA-CT-116)". In Semester-IV, there are two theoretical papers "Elective Special Paper II (BOTA-CT-120)" and "Elective Special Paper IIII (BOTA-CT-121)"; and also one practical paper "Elective Special Paper Practical (BOTA-CT-122)". The students will be provided the choice to select the Elective Special Papers for Semester-III and IV at the start of Semester-III from the set of eight combinations of papers including Genetics and Bioinformatics; Microbiology; Molecular Plant Pathology and Fungal Biotechnology; Plant Biochemistry; Plant Genetics and Molecular Breeding; Plant Physiology and Pharmacognosy; Pteridology, Palaeobotany and Palynology; and Taxonomy of Angiosperms and Biosystematics. The students would be required to select any one out of the eight for the elective special papers.

The Course Objectives and Course Learning Outcomes for the Elective Special Papers BOTA-CT-116, BOTA-CT-120, BOTA-CT-121 and BOTA-CT-122 are as follows.

I. GENETICS AND BIOINFORMATICS

COURSE OBJECTIVES:

Genetics is the study of genes, the fundamental unit of heredity. The importance of studying genetics is enormous. Sydney Brenner once said that in the present century all biology would be gene-centred and all biologists would be geneticists. Though the study area of Genetics is manifold, still the main concern of Genetics is the study of heredity and the information of life imprinted in DNA. On the other hand Bioinformatics is rather an interdisciplinary field mainly concerning with the development of methods and software tools for understanding biology. Bioinformatics has particularly become important after the advent of various genome projects. Therefore Genetics with Bioinformatics would be an integrated field for studying the misery of life.

COURSE LEARNING OUTCOMES:

- Students will learn the concepts of gene in pre-DNA era.
- Students will gain knowledge on the laws of genetic inheritance, gene pyramiding, and also about population genetics.
- Students will gain knowledge on the different types of recombination and genetic markers.
- Students will get detail information of PCR, its variants and their applications.
- Students will have in depth knowledge on the use of different bioinformatics tools, homology modeling, etc.

II. MICROBIOLOGY

COURSE OBJECTIVES:

The course aims to increase understanding of the students with about the mechanism of genetic recombination and advantage of this process in genetic engineering. Students will also learn about the modern day chemotherapy and few concepts of immunology. The course aims to increase the understanding of the students about the importance of microbes in industry. The student will be

taught role of microorganisms in production of antibiotics, alcohols, enzymes etc. The students will gain knowledge about the recent advances in the field of industrial microbiology. The course aims to increase the understanding of the students about the importance of microbes in environmental and agricultural microbiology. The student will be taught role of microorganisms in maintaining the functioning of ecosystem. The students will also gain knowledge about the possible roles of microorganisms in bioremediation. The students will also gain knowledge about the diversity of microorganisms in extreme environments.

COURSE LEARNING OUTCOMES:

- ❖ Students will be able to understand and appreciate role of genetic recombination in bacteria.
- ❖ Students will develop theoretical skills of medical microbiology and understand the molecular mechanisms underlying the gene cloning.
- ❖ Students will be able to understand and appreciate fermentation technology.
- ❖ Students will develop practical skills in microbiological techniques and appreciate the versatile role of microbes in day to day products.
- ❖ Students will be able to understand and appreciate role of microbes in sustainable environment.
- ❖ Students will also develop both theoretical and practical knowledge regarding study of microbial diversity from extreme environment.
- ❖ Students will be able to appreciate the resourceful part of microbes in overcoming major environmental problems of the world.

III. MOLECULAR PLANT PATHOLOGY AND FUNGAL BIOTECHNOLOGY

COURSE OBJECTIVES:

This course aims to give an overall knowledge of fungal biotechnological developments with special reference to agriculture and environment. Details of the molecular biological concepts are given to the students to study, analyze, and control of plant diseases. Developments of immunology, molecular techniques of defense genes, and classical aspects of plant virology, mycology and also of other pathogens are taught. Students are given knowledge in transgenics, biocontrol product formulations, mushroom cultivation etc. Concept of plant health clinic/seed health clinic also given to the students. Genomics, proteomics and use of bioinformatics in host-pathogen interaction are also taught in this paper.

COURSE LEARNING OUTCOMES:

- ❖ Students will understand molecular events of host-pathogen interaction.
- ❖ Students will learn how to prepare biocontrol products.
- ❖ Students will learn different diagnostic techniques applied in pathology and will also be able to diagnose plant disease for proper recommendation of control measures.
- ❖ Students will learn basics of research and publications in molecular as well as classical plant pathology.

IV. PLANT BIOCHEMISTRY

COURSE OBJECTIVES:

This course aims to aims to acquaint the students with the fundamentals and recent advances in the field of Plant Biochemistry. The course attempts to teach the students with some fundamental

topics like calvin cycle, starch biosynthesis, sucrose transportation, signaling to advances in the tools and techniques required for the evaluation of genome and proteome.

COURSE LEARNING OUTCOMES:

- Students will have a complete understanding of the structural and functional details of the photosynthetic apparatus, in depth knowledge of the calvin cycle and CO_2 concentrating pathways that leads to the synthesis of sucrose and starch.
- Students will gain knowledge about the details of starch biosynthesis and sucrose transportation in plants.
- Students will gain knowledge of the mechanism of protein sorting and degradation, nitrogen and sulfur metabolism, hormonal control of plant growth, photoperiodism and the role of phytochrome, flower and fruit development.
- Students will have an in depth knowledge of plant signaling mechanisms and the pathways associated with it, secondary metabolites and the major pathways of their biosynthesis, and the mechanisms controlling the regulation of genome expression.
- Students will gain knowledge regarding the major instruments used in the field of biochemistry and learn some basic aspects of computational biochemistry.

V. PLANT GENETICS AND MOLECULAR BREEDING

COURSE OBJECTIVES:

Students will gain knowledge about the theory and practices of plant genetics and molecular breeding. They will understand the basic principles of inheritance of qualitative and quantitative characteristics. Quantitative characteristics mainly governed by many genes which are polygenic inheritance or QTL based trait expression. Breeding is the subject where students can have knowledge about the improvement of crop varieties by applying the basic & fundamental aspects of genetics and breeding methods. Conventional breeding process has some drawbacks which can be rectified by using the modern technique of molecular breeding which is molecular marker based breeding technique. Student will learn about modern technique of molecular breeding – which include MAB/ MAS/ GWAS for QTL mapping and identification to develop new climate resilient crop varieties (mainly rice). Students can have some ideas about the Green Revolution, how it was started in 1960s by using the Mendelian genetic inheritance principle in the breeding programme to improve the crop varieties.

COURSE LEARNING OUTCOMES:

- Students will understand about pre-breeding (interspecific hybridization) for introgression of genes/QTLs from wild relatives. Wild relatives are the reservoir of many important traits such as Abiotic/Biotic stress tolerance.
- Students will also learn the technique for increasing the genetic base of crop varieties in terms of yield & quality of crop plant (especially in Rice).
- The students will understand the controversy of GM Crops and its ethical issues and ecological concern.
- Students will gain knowledge on crop improvement because food grain production must be increased to feed more than nine billion people by 2050.

VI. PLANT PHYSIOLOGY AND PHARMACOGNOSY

COURSE OBJECTIVES:

The course is designed for delivering comprehensive knowledge about different classes of secondary metabolites and new generation plant hormones with their prospective uses in the field of medicine and agriculture. The course will also deal with different aspects of advance topics and the techniques of modern research in plant physiology and pharmacognosy. The chapters are designed to equip students acquainted with vast and dynamic area of plant science research associated with molecular mechanism of signal perception and transduction, membrane transport, gene expression, green nano-techniques for therapeutic purposes, proteomics, bio-separation techniques and identification of bio-molecules through spectroscopic analysis.

COURSE LEARNING OUTCOMES:

- ❖ Students will learn the metabolite flux in plants and their homeostasis, compartmentation and augmentation with programs of differentiation.
- ❖ Students will acquire knowledge about phenolics, alkaloids, glycosides and terpenoids; their biosynthesis in plants and ecological significance.
- ❖ Peptides and brassinosteroids are now emerging field of plant hormone research. Through this chapter students will achieve knowledge molecular mechanism of new phytohormone research.
- ❖ Students will be learning perception and processing of external information by cells through signal transduction mechanism and their functional translation through gene expression an editing.
- ❖ Students will understand the action and pharmacology of herbal drugs, their channelling inside the cells and specific nano-carriers for precise targeting of herbal drugs.
- ❖ Students will know the stress mitigation measures by plants and molecular interaction with environment.
- ❖ Students will recognize the quality control attributes of herbal drugs as per international guidelines.
- ❖ Students will learn chromatographic techniques of separation of biomolecules which will help them independent during research designing.
- ❖ Also, the students will acquire different techniques of spectroscopy for understanding the nature of biomolecules in modern phytochemical research.

VII. PTERIDOLOGY, PALAEOBOTANY AND PALYNOLOGY

COURSE OBJECTIVES:

The course aims to provide an insight of the various physiological, biochemical and molecular changes associated with the diversification of land plants and the mechanisms of their adaptive strategies. The course also focuses on the role of different species in the ecosystem and bioprospecting.

COURSE LEARNING OUTCOMES:

- ❖ Students will learn about the role of various growth hormones in lower groups of plants and their regulatory mechanisms.
- ❖ Students will learn about the interactions of various lower groups of plants with micro-organisms and the strategies followed by them in conduction of water and photosynthates.
- ❖ Students will gain knowledge regarding stress tolerance mechanisms of bryophytes nad pteridophytes with special regards to dessication and will also be learning about bryophyte and pteridophyte model plants.

- ❖ Students will gain knowledge regarding the fundamentals, scopes and applications of palynology as a subject.

VIII. TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

COURSE OBJECTIVES:

This course aims to introduce the students to elaborate and advanced concepts of ICN, taxonomy and systematics, evolutionary inference among the taxa, biodiversity conservation, important families, their classification and role of taxonomic evidences, application of barcode markers in delineating species boundary, traditional knowledge and biodiversity conservation.

COURSE LEARNING OUTCOMES:

- ❖ Students will learn about the role of ICN in Plant Taxonomy.
- ❖ Students will gain knowledge on the usage of taxonomic evidences as delineate factor for angiosperms and their classification
- ❖ Students will understand the concepts of are phonetic and cladistics.
- ❖ Students will be able to understand the concept of molecular systematics and get acquainted with the preparation of phylogenetic trees and understand the importance in modern biology.
- ❖ Students will learn the concept of Ethnic knowledge and Biodiversity conservation.

COURSE CONTENTS

*ELECTIVE SPECIAL PAPER I

I. GENETICS AND BIOINFORMATICS

1. Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers.
2. Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.
3. Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations.
4. Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

II. MICROBIOLOGY

1. Transcription: Organization of transcriptional units Mechanism of transcription of prokaryotes-Structure and function of RNA polymerase, RNA processing (Capping, polyadenylation, splicing, introns and exons).
2. Translation: Ribonucleoprotein, Salient features of genetic code, structure of mRNA, rRNA, tRNA. polycistronic mRNA in bacteria, translation mechanism in bacteria, Post-translational modification.
3. Regulation of gene expression in prokaryotes: Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*, *ara* and *tol* operons, with emphasis on recent advances.

4. Gene cloning: Plasmid biology (Types; Detection and purification; Replication); Genetic engineering (Splicing of DNA; Insertion of DNA into vector; Detection of recombinant molecules; Expression of cloned genes; PCR and Its variants.
5. Genetic recombination: Genetic recombination processes: Role of rec proteins in homologous recombination. Conjugation: Discovery, F+, F- and Hfr cells, types of Hfr; F+ and F- and Hfr and F- genetic crosses. Mechanism of conjugation. Sexduction, conjugational transfer of colicinogenic and resistance transfer factors. Genetic mapping. Plasmid Replication and Incompitability, Control of copy number.
6. Chemotherapy: General principles; classification of antibiotics; Chemistry, mode of actions, and antimicrobial spectra of antibacterial and antifungal antibiotics; Mechanism of antibiotic resistance in prokaryotes.
7. Immunology: Immunoglobulin classes; Formation and structure of Immunoglobulin G; Antibody-antigen reactions; Immunodiagnostics.

III. MOLECULAR PLANT PATHOLOGY AND FUNGAL BIOTECHNOLOGY

1. Mycorrhizae – Molecular tools for identification and detection, PCR cloning of genes from AM fungi; RAPD and ITS analysis orchid mycorrhizal fungi. Analysis of gene expression in AM fungi; Genetic fingerprinting of ectomycorrhizal fungi. Mycorrhiza helper bacteria (MHB).
2. Commercialization of Biocontrol and Entomopathogenic fungi.
3. Isoflavonoid and tepenoid phytoalexins: Biosynthesis; role in disease defense mechanism; Detoxification mechanisms; Elicitors of Phytoalexins; Manipulation of phytoalexin synthesis in plants.
4. Molecular diagnostics: Early detection of plant pathogens in soil, water and plant tissues using immunodiagnostics.
5. Resistance mechanisms in plants: Biosynthetic pathways for the main plant antimicrobials, PR proteins.
6. Plant response to abiotic and biotic stress: Mechanism of biotic and abiotic stress tolerance; Hypersensitivity response (HR) and systemic acquired resistance (SAR).

IV. PLANT BIOCHEMISTRY

1. Basic Chemistry: Structure of atom and molecules; electronic theory of valency; atomic and molecular orbitals, hybridization; electrophilic and nucleophilic substitution reactions; dipole moments, electron displacements (inductive, electromeric, mesomeric effects); resonance; hydrogen-bonding; types of organic reactions - carbocations, carbanions and free radicals.
2. Molecular biology of photosynthetic system: Organization of chloroplast genome in higher plants; chloroplast gene expression and protein synthesis; structure and function of light receptors and reaction centers; plant pigments - types, structural differences and applications.
3. Calvin cycle and its regulation: Gene organization, expression and regulation; RUBISCO - folding and assembly, activation, regulation; photorespiration.
4. CO_2 concentrating cycles: Operation of C4 pathway, variants, regulation; CAM as survival mechanism, gas exchange phases and regulation regulation.
5. Sucrose and starch metabolism: Sink-source concept, relation with hexose monophosphate junction; sucrose synthesis, storage, transport - phloem loading and unloading; regulation; structure and function of transitory starch; synthesis pathways, branching and debranching enzymes, regulation; starch transportation and degradation; starch-sugar interconversion.

V. PLANT GENETICS AND MOLECULAR BREEDING

1. Plant breeding: An overview, objectives, and biotechnology in plant breeding.
2. Methods in plant breeding: Breeding for self and cross pollinated crops including clonally propagated crops; breeding for Hybrid cultivars; sexual hybridization and wide crosses and pre-breeding for germplasm enhancement.
3. Tools and techniques of plant breeding: Cytogenetic basis of plant breeding- variation in chromosome number, mutation, fertility regulation mechanism; gene recombination in plant breeding.
4. Population genetics and Association mapping: The theory of allele frequencies, the gene-pool concept and Hardy-Weinberg principle, several evolutionary forces potentially cause changes in allelic frequencies-mutation, genetic drift, and natural selection; linkage and linkage disequilibrium, GWAS.
5. Evolutionary genetics: Overview, molecular variation, protein variation, DNA sequence variation, molecular phylogenies, mode of speciation and genome evolution; rates of molecular evolution and molecular clock.

VI. PLANT PHYSIOLOGY AND PHARMACOGNOSY

1. Regulation of secondary metabolites: Characteristic features and origin of secondary metabolites; Regulation of enzyme amount and activity in secondary metabolism; Compartmentation and turnover; Integration of metabolism in programs of differentiation and development; Action of signals and sequential gene expression
2. Plant phenolics: Properties, Structural diversification and Occurrence; Classification; Biosynthetic Origin; Phenyl Propanoid Pathway; Flavonoid: Major Classes and variation in hydroxylation; Isoflavones: Biosynthesis of Rotenone; Anthocyanins; Physiological role of Phenolics and Flavonoid; Enzymology and regulation of Phenyl Propanoid pathway: PAL, Hydroxylase and Phenolase, Methyltransferase, Vacuolar transport and glycosylation; Ecological significance and therapeutic implications.
3. Alkaloids, cyanogenic glycosides and glucosinolates: Classification, Occurrence physico-chemical and biological properties; Pyrrolidine, Piperidine, Isoquinoline, Quinolizidine, Tropane and Indole alkaloids - their distribution, biosynthesis and function. Structure, properties, detection, metabolism and physiological role of Cyanogenic glycosides and Glucosinolates;
4. Terpenoids and steroids: Terpenoids: Classification, occurrence and biological properties; Biosynthesis and metabolic regulation; Health benefits and ecological significance of terpenoids; Saponins and sapogenins: Sterols, steroids, steroidal alkaloids - their distribution, biosynthesis and function.
5. Hormone like action of plant peptides, jasmonates and brassinosteroids: Identification of peptide signals; Post-translational modification and function of peptides; Physiological role of Systemin, Phytosulfokine, Clavata, RALF and ENOD40 peptides; Herbivore damage induced systemic defenses through Jasmonic Acid biosynthetic pathway; Structure, occurrence and metabolism of Brassinosteroids; Brassinosteroids signaling pathway and prospective uses in agriculture.

VII. PTERIDOLOGY, PALAEOBOTANY AND PALYNOLOGY

1. Introduction; distribution of pteridophytes in India; endangered pteridophytes and their conservation.
2. History of pteridophyte classification; any molecular classification.
3. Stomata: origin, types and ontogenetical interrelationships.
4. Stelar types and evolution; petiolar vascular types and evolution.
5. Studies on the groups: Ophioglossaceae, Marattiaceae (including fossil members), Schizaeaceae, Gleicheniaceae, Cyatheaceae, Polypodiaceae.
6. Biology and control of Bracken fern (*Pteridium aquilinum*).

VIII. TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. International Code of Nomenclature: Principles, articles, recommendations and special provisions; application of code with problems; nomenclature of cultivated and hybrid plants; taxonomic hierarchy. Biocode and Phylocode
2. Indian flora. Endemism- in Indian perspective
3. Migration, dispersal and discontinuous distribution of plants
4. Biodiversity Conservation: IUCN categories, Effects of Rio de Genero world summit, Conservation Hotspots, India as a Megadiversity country; Ramsar sites, Methods conservation. Biodiversity protected areas in India.

COURSE TYPE: PRACTICAL (P)

COURSE CODE: BOTA-CP-117

Credit: 2 **Full Marks: 50** **Total working hours: 96**

GROUP A: GENETIC ENGINEERING AND BIOINFORMATICS

Marks: 25 **Total working hours: 48**

1. Isolation of plasmid DNA and purity check.
2. Restriction digestion of the plasmid DNA and fractionation in agarose gel electrophoresis.
3. *In vitro* gene cloning through PCR amplification.
4. Analysis of statistical data through softwares such as Excel and SPSS.
5. Sequence analysis softwares and accessing biological data.
6. Nucleic acid and protein sequence analysis.
7. Phylogenetic analysis.
8. Basic techniques of molecular modeling.

GROUP B: BIOSTATISTICS

Marks: 25 **Total working hours: 48**

1. Measurements of central tendency.
2. Measures of dispersion.
3. Determination of tests of significance: Chi square test, t-test.
4. Determination of relationship between variables using correlation and regression analysis.
5. Analysis of variance; one way, two way

COURSE CODE: BOTA-CP-118

Credit: 2 **Full Marks: 50** **Total working hours: 96**

GROUP A: ECOLOGY

Marks: 25 **Total working hours: 48**

1. Estimation of dissolved oxygen content.
2. Estimation of dissolved carbonate & bicarbonate content.
3. Determination soil pH.
4. Study of ecological characters of plants.
5. Determination of a population growth curve from given data.
6. Ecological studies of grassland/herbland.
7. Ecological studies of a wetland.

GROUP B: PHARMACOGNOSY

Marks: 25 **Total working hours: 48**

1. Quantitative microscopy of leaf drug:
   i) Stomatal Frequency
   ii) Stomatal Index
   iii) Palisade Ratio
   iv) Vein Islets
   v) Vein Termination Number
2. Qualitative detection of alkaloids and steroids in drug plants.
3. Quantitative estimation of total flavonoids content of drugs.
4. Study of powdered drugs – physical, chemical and microscopic examinations.
5. Anatomy of tea leaves and detection of sclereids for adulterant determination.
6. Choice of solvents for extraction of plant metabolites.
7. Study of unorganized drug: starch.

SEMESTER IV

COURSE TYPE: THEORETICAL (T)

COURSE CODE: BOTA-CT-119

Credit: 3.2 **Full Marks: 80 [50 (T) +30 (IA)]** **Total lecture hours: 64**

COURSE OBJECTIVES:

This course aims to familiarize the students with sustainable use of bio resources. The subject will focus on the importance of medical plants and their conservation strategies. The students will be taught about the contribution of various naturalists in biological sciences. This paper also aims to introduce theoretical aspects of imaging, biochemical and molecular techniques that are being exploited in research in biological sciences.

COURSE LEARNING OUTCOMES:

- Sudents will learn about the usage of bio resources and their sources.
- Students will get detailed study of concept of origin of life.
- Students will get information about the Natural History Societies and museums across the world.
- Students will understand the concepts, techniques and applications of various techniques used in biology.

COURSE CONTENTS

GROUP A: BIORESOURCE UTILIZATION, MEDICINAL PLANTS AND NATURAL HISTORY

Marks: 25 Total lecture hours: 32

1. Traditional knowledge on the use of Bioreesources: - Utilization, need, survey, conservation; Non-Timber Forest Produces.
2. Microbial Resources: Biofertilizers, Biocontrol agents, Mycorrhizae; Vermicompost- their utilization in agricultural practices.
3. Diversity, sources and importance of Medicinal plants, *in-situ* and *ex-situ* conservation Propagation and harvesting of Medicinal plants
4. Origin of life; Spontaneous generation versus biogenesis; fermentation; germ theory of disease.
5. Lamarck & Darwin: The Lamarckian heritage; Charles Darwin; Theories of Darwin; Darwinian Evolution and religious attack; Support for Darwin.
6. Noted Naturalists: George Charles Wallich, Theodosius Dobzhansky, Birbal Sahni, Alfred Russel Wallace, David Attenborough, E. O. Wilson, Edward Forbes, J.C.Bose, R.L.Brahmachari and others.
7. Natural History Societies and museums : Bombay Natural History Society; Bengal Natural History Museum, Darjeeling; Indian Museum, Kolkata; Asiatic Society of Bengal, Kolkata; British Natural History Society and Museum, London; Musée des Confluences (Lyon); Muséum national d'histoire naturelle (Paris); American Museum of Natural History, New York City etc.

GROUP B: TECHNIQUES IN BOTANY

Marks: 25 Total lecture hours: 32

1. Imaging Techniques: Principles of microscopy. Principles and applications of light microscopy, fluorescence microscopy, phase contrast, confocal microscopy and electron microscopy (Transmission and scanning electron microscopy).
2. Bioseparation Techniques: Principles and application of chromatography, HPLC and GLC, Electrophoresis: AGE, PAGE, SDS-PAGE, Isoelectric focusing and 2-D.
3. Spectroscopic Techniques: Principles of Colorimetry and Spectrophotometry. Biological Applications of UV-Visible Spectrophotometry, Mass spectroscopy and Infrared Spectroscopy.
4. Immunochemical and Radioisotope Techniques: General Principles. Antigen and Antibody Interaction. Antibody Production. Immuno-diffusion. Radioimmunoassay (RIA). Enzyme Linked Immuno-sorbent Assay (ELISA). Fluorescent Immunoassay (FIA); Use of radioisoptes in biology.
5. Basic principles and applications of molecular techniques: RAPD, AFLP, RFLP, ISSR,SSR, PCR and its variants; functional genomics and proteomics.

COURSE CODE: BOTA-CT-120		
Credit: 3.4	**Full Marks: 85 [50 (T) +35 (IA)]**	**Total lecture hours: 64**

*ELECTIVE SPECIAL PAPER II

I. GENETICS AND BIOINFORMATICS

1. Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing.
2. Genetic and physical mapping of a genome: Recombination and genetic marker viz. microsatellite/ minisatellite markers, RFLP, RAPD, SNPs, FISH & Chromosome painting, clone countig, physical mapping, sequencing and annotation. CpG islands, isochore and gene densities.
3. Gene amplification and PCR: Basic principles and methodologies of PCR, design of PCR primers, RT-PCR and Real-Time PCR and their utility.
4. Evolution of Protein and Genetic Code: Protein or nucleic acid first? The RNA world, Evolution of Protein synthesis, Evolution of genetic code.

II. MICROBIOLOGY

1. Introduction to industrial microbiology: Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology.
2. Production of antibiotics: penicillin, streptomycin; Amino acids: Glutamic acid, Lysine etc.
3. Production of alcohols and organic acids: Alcohol Production - Malt- Beverages, Production of Beer, Production of Wines, Distilled Beverages or Liquors, Vinegar Production, Organic Acids - Citric, Lactic, Acetic, Propionic.
4. Production of enzymes: Extracellular – amylase, protesases, pectinases, lipase, cellulases
5. Food microbiology and fermented products: Vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods.

III. MOLECULAR PLANT PATHOLOGY AND FUNGAL BIOTECHNOLOGY

1. Defense related enzymes: Occurrence, properties, isolation, purification, biochemical and immunological characterization, induction, possible functions.
2. Genetic manipulation of industrially important fungi: Strain improvement, recombinant DNA technology, choice of vectors for cloning, stabilization of transformants, application in genetic improvement of edible mushroom and biocontrol fungi
3. Fungal protoplasts: isolation, fusion and culture, regeneration and reversion.
4. Production of industrially important enzymes: alfa-amylase, cellulose, laaccase, pectinase, and protease from filamentous fungi.
5. Mushroom cultivation and development.
6. Fungal Genomics; Broad Institute and fungal genome projects.

IV. PLANT BIOCHEMISTRY

1. Protein sorting and degradation: Machinery of protein sorting; targeting to mitochondria, plastids, nucleus, ER, vacuole; Protein modification in Golgi apparatus; protein degradation - lysosome and proteasome mediated, non-enzymatic proteolysis.
2. Nitrogen and sulfur metabolism: Nitrate uptake, nitrate reduction, ammonia assimilation; regulation of glutamine synthetase/ glutamate synthase cycle; biological nitrogen fixation -

mechanism and regulation, nitrogenase - types, structure and regulation; sulfur chemistry and function; incorporation of sulfur in to amino acids, reductive sulfate assimilation pathway.

3. Plant growth and regulation: Embryogenesis - gene expression, role of transcription factors; auxin mediated growth; cell wall biosynthesis; Phytohormones, brassinosteroids, jasmonic acid, salicylic acid - chemistry, metabolism and mode of action.
4. Sensory photobiology: Photoperiodic pathway, phytochrome - structure, physico-biochemical properties, mode of action, phytochrome gene family; cryptochrome and blue light responses, physiological activities, xanthophyll cycle.
5. Flower and fruit development: Photoperiodism, vernalization; floral meristems, floral organ identity, genetic control of flowering, ABC model; hormonal control of fruit development, physiology and biochemical changes during ripening, genetic regulation.

V. PLANT GENETICS AND MOLECULAR BREEDING

1. Genomics: Structural and functional genomics, comparative genomics- and synthetic biology; reverse-genetics: dissecting biological processes by inhibiting gene expression; and Epigenomics.
2. Alien gene transfer and evolution of major crop plants: Methods of alien gene transfer for crop improvement with rice as Model crop. Overview of intragenesis and cisgenesis.
3. Plant Genetic Resources and their Regulatory System: Origin of crop plant, plant domestication, agro-biodiversity, Conservation and utilization of plant genetic resources. CBD, and ITPGRFA, Intellectual Property Rights; Plant Variety Protection and Farmers' Rights Act.
4. Molecular plant breeding: Introduction; tools of molecular breeding; application of molecular markers and functional markers system in plant breeding, identifying markers and trait associations; molecular markers used in model crop rice. Rice breeding in post genomic era.
5. Quantitative Genetics and QTLs Mapping: Quantitative characteristics; polygenic inheritance, statistical methods for analysing quantitative traits, heritability- broad sense and narrow sense and genetic advance.
6. Development of mapping population - RIL/NIL/double haploid including CSSL/BIL lines; QTLs mapping, and artificial selection; QTL mapping by linkage analysis and by association analysis (GWAS); molecular markers and construction of linkage map; map based cloning.

VI. PLANT PHYSIOLOGY AND PHARMACOGNOSY

1. Signal perception and transduction: Overview; Receptors; Quantitative Ligand binding; G-proteins and Phospholipid signaling; Cyclic nucleotides; Role of Protein Kinases; Diseases associated with G-Protein signaling; Receptor Tyrosine Kinases (RTKs); RAS and other Proto-oncogenes; JAK-STAT Pathway; Integrins; Toll Gate Receptors; Lipid Hormone Signaling; COX targets.
2. Chemistry and pharmacology of herbal drugs: Classification of active plant constituents and phytotherapeutic properties; Routes of drug administration; Adsorption, metabolism and fate of drugs; Mechanism of drug action and tolerance; Basic concept and application of network medicine.
3. Transport across membrane and drug action: Types of transport (Simple Diffusion, Passive-Facilitated Diffusion); Active transport – Primary and Secondary Group Translocation;

Transport ATPases; Transport by Vesicle Formation; Distinction of Channels and Transporters; Drug Action and potential role of Transporters; Transporters in Pathogens as Drug Gateways or Targets; Transporter Structure-Function relationship; Nernst Equation and Equilibrium Potential

4. Regulation of gene expression in plants: Plant Gene structure and Expression; Regulatory Mechanisms- control of Transcription; Post-transcriptional control of gene expression; Eukaryotic Promoter; Transcription Factors and Enhancers; DNA-binding Motifs; Chromatin Remodeling; Prokaryotic Gene Regulation- *Lac* and *Trp* Operon; RNA Editing and Alternative Splicing mechanism
5. Natural product based nanomedicine: Herbal Drug nanoparticles; Nanoparticles Classification; Novel Drug delivery System: Nano Carriers for Herbal Therapy; Polymeric Nanoparticles; Metallic Nanoparticles; Green synthesis and characterization of Metallic Nanoparticles; Solid-Lipid Nanoparticles and Nanostructured Lipid Carriers; Liposomes and Micro-emulsions; Carbon Nanotubes.

VII. PTERIDOLOGY, PALAEOBOTANY AND PALYNOLOGY

1. Cytogenetics of Ferns: I. Analysis of species complexes. II. Polyploidy (Origin of polyploidy, Polyploidy in Homosporous and Heterosprous Ferns, Geographical distribution of polyploids). III. Apogamy (including Agamospory), Apospory and Apomixis. Hybridization, Genetic load.
2. Biochemical and Physiological aspects of Gametophyte differentiation and development. Gametophyte types. Mating systems in Ferns. Antheridogen and its mechanism of action in sex expression.
3. Shoot apical meristem. Leaf origin and development. Root apical meristem.
4. Fern ecology: Tolerance of desiccating conditions, sporophyte-sporophyte interactions, sporophyte-prothallus interactions, prothallus-prothallus interactions.
5. Culture of Fern gametophytes.

VIII. TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. Survey of Taxonomic Literature: Dictionaries, Indices, Monographs, Manuals, Floras, Journals, and taxonomic websites; Genebank
2. Use of Herbaria; role of Botanic Gardens in the 21st Century.
3. Biosystematics: definition, importance and categories. Major areas of biosystematic studies: *Palynology*, Embryology, Micromorphology, *Phytochemistry*, *Cytology*, *Protein*, *DNA*
4. Remote sensing & GIS.
5. Analysis of data; commonly available software, construction of dendrograms

COURSE CODE: BOTA-CT-121

Credit: 3.4 **Full Marks: 85 [50 (T) +25 (IA)]** **Total lecture hours: 64**

*ELECTIVE SPECIAL PAPER III

I. GENETICS AND BIOINFORMATICS

1. Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.
2. From metabolism to cell: Aerobic and anaerobic metabolism, Early fossilized cells, Prokaryotes and Eukaryotes, Evolution of eukaryotic organelles.
3. Comparative genomics through Codon Usage analysis and related software. Sequence Alignment, Phylogeny analysis: related algorithms and software.
4. Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTAL W and CLUSTAL X for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned set of sequences, updates and internet resources; methods of phylogenetic analysis.
5. Homology modelling: related servers and software. Validation of a model; Structure based phylogeny and its implications.
6. Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

II. MICROBIOLOGY

1. Issues and scopes of environmental biotechnology: Microorganisms and Environment- Physiological state of microorganisms in the environment, nutrient cycling process, carbon cycle, nitrogen cycle, sulphur cycle
2. Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, Biobeneficiation of gold ores. Microbially enhanced oil recovery
3. Biodegradation of organic pollutants: Xenobiotics, Mechanisms and factors affecting biodegradation; Bioremediation, Biostimulation and Bioaugmentation. *In situ* and *ex situ* bioremediation technologies. Bioremediation of oil spills; Phytoremediation; Use of GMO in bioremediation.
4. Waste water treatment: Waste water characterization and its significance: COD, BOD, Inorganic constituents, solids, biological components. Primary, secondary and tertiary treatment of waste water.
5. Understanding microbial diversity in the environment: Culture dependent approaches and culture independent approaches; Metagenomics-Brief introduction and applications
6. Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles

III. MOLECULAR PLANT PATHOLOGY AND FUNGAL BIOTECHNOLOGY

1. Resistance genes : Gene for gene concept; features of cloned resistance genes; R gene specificity, TIR domain, NBS Domain, other R gene domains.
2. Signalling in plant disease resistance mechanisms: Different types of signals; Interplay of downstream signaling pathways; NPR1 independent pathways.

3. Genetic engineering of plants for disease resistance: organization of genes controlling disease resistance; methods of gene transfer; strategies for development of transgenics.
4. Molecular diagnostics: Nucleic acid based techniques such as pathogen specific marker; hybridization technique; PCR based techniques; gene array based techniques; quantitave PCR.
5. Plant viruses- movement and interactions with plants; Transmission and cross protection.
6. Development of virus free plants through tissue culture. Mass multiplication.
7. Recent developments in virus management: Transgenics through RNAi and VIGS; Tissue culture-mediated and *in planta* transformation.

IV. PLANT BIOCHEMISTRY

1. Plant signaling: Overview; receptors; G-proteins and phospholipid signaling; role of cyclic nucleotides calcium-calmodulin cascade; diversity and role of protein kinases; sucrose sensing mechanism; abiotic stress related signaling - ROS generation, role of transcription factors, SOS pathway, heat shock proteins, anti-freeze proteins; stress induced genes and proteins; genetic engineering for stress tolerance.
2. Secondary metabolites: Overview, classification, functions; major biosynthetic pathways; biosynthesis of terpenoids, alkaloids, phenols; compartmentations and sequestration of metabolites, long distance transport; metabolic engineering.
3. Genome expression and regulation: RNA polymerases and transcription cycle, RNA splicing and editing; mRNA transport; Genetic code - basic principles and exceptions; proteins biosynthesis; gene regulation, operon concept, post transcriptional gene silencing, concept of RNAi - miRNA and siRNA; post translational regulation, ribozymes, Genetic imprinting.
4. Instrumentation principles: Gel electrophoresis, IEF, 2D gel electrophoresis, DIGE, iTRAQ; radioisotope technology; spectroscopy and chromatography techniques; tools of analyzing DNA-protein, RNA-protein and protein-protein interaction; DNA and protein microarray; GFP tagging.
5. Computational Biochemistry: Sequence alignment, local and global, multiple sequence alignment; concept of databases with examples; protein sequence analysis, ExPASy proteomic tools, prediction of physiochemical properties, secondary structures, hydrophobicity; CATH, SCOP and VAST; phylogenetic analysis based on DNA, RNA and proteins; molecular modelling.

V. PLANT GENETICS AND MOLECULAR BREEDING

1. Marker Assisted Breeding: Molecular markers as new efficient tools in breeding, MAS for tagging of agronomically important traits; trait integration-theory and practice, foreground and background selection, concept of graphical genotypes, elimination of linkage drags, breeding informatics, SEG-Map.
2. Advanced Breeding techniques: Whole-genome sequencing (WGS), GBS, genome function, SNP discovery, allele mining, 3k RGP and phylogenomics for crop improvement.
3. Transgenic technology for crop improvement: GM crops and traits, Golden rice, Bt-brinjal; Bt-cotton, Bt toxin (Cry protein) gene structure analysis and expression for insect resistance; Genome editing with CRISPR-CAS9 technology; advantages and ecological concern of GM crops.
4. Breeding for Biotic and Abiotic stress Resistance: Genetic basis and breeding for resistance to diseases and insect pests. Genetic and physiological basis of abiotic stress tolerance- flood, drought, salinity, cold for climate ready crop varieties and breeding for nutritional quality.
5. Proteomics and Transcriptomics: Principles and Techniques of proteomics and

transcriptomics analysis and application in plant breeding. SAGE, RNase protection assay, nuclear run-on assay; yeast two-hybrid assay, FRET; EMSA, DNase I footprinting, ChiP.

VI. PLANT PHYSIOLOGY AND PHARMACOGNOSY

1. Stress physiology: Drought resistance strategies; Osmotic adjustment; Adaptation of CAM plants under drought stress; ABA signaling and drought tolerance; Heat stress and heat shock; Temperature affecting membrane stability; HSP mediated thermo tolerance and signaling pathways; Chilling and freezing tolerance; Transcription factors regulating cold-induced gene expression; Salinity stress; Strategies of salt tolerance; Hypoxic and anoxic stress; Strategies for submergence tolerance and oxygen deficit.
2. Chromatography: Introduction, History, Classification and Types; Basic principles of Column Chromatography: Partition, Ion-Exchange, Gel Permeation and Affinity system; Normal and Reverse Phase; Partition Co-efficient and Nernst Distribution law; Packing techniques and elution system in column chromatography; Detection of compounds; Theory of chromatography: Chromatogram, Solute retention and capacity factor; Column efficiency; Peak resolution; HPLC and GLC; Applications of Chromatography
3. Quality control of herbal drugs: Herbal technology; Organoleptic, Microscopic, Biological, Chemical and Physical attributes; Pharmacopoeia; Guidelines for the assessment of herbal medicines; Drug adulteration; Determination of microbial contamination and Aflatoxin; Identity, purity and strength of herbal drugs; Detection of pesticide and heavy metals; TLC profile and chemical finger-print.
4. Detection of molecular mass and proteomics: Mass Spectrometry and Spectrum -Basic Principles; Detection of Mass Spectrum; Components of Mass Spectrometer; Ionization methods in MS; MALDI and APCI; Mass analyzers; Type of peaks and fragmentation rules; Determination of molecular mass; GC-MS; Application of Mass Spectrometry; Basic Concept of Proteomics; Tandem Mass Spectrometry; Determination of peptide sequences.
5. Spectroscopy: Electromagnetic Radiation; Properties of EM wave; Principles of Spectroscopy; Molecular orbital; Electronic transitions; Lambert Beer's Law; Chromophore and Auxochromes; Absorption and intensity shifts; Instrumentation of UV-Visible Spectrophotometer and applications; Molecular vibrations- Stretching and Bending; Classification of Infra-Red region; Harmonic Oscillation; IR correlation diagram; Instrumentation of IR Spectrophotometer; -OH and –CH stretching; Use of IR spectra; Nuclear Spin states; Principles of NMR; Chemical shift; Proton NMR; Spin-spin coupling; NMR Instrumentation and application in biological field.

VII. PTERIDOLOGY, PALAEOBOTANY AND PALYNOLOGY

1. Antiquity of life; Major events in the Precambrian- early life forms, Indian records, stromatolites and palaeoecology.
2. Environmental changes during Permian, Permo-Carboniferous floral proviences. Early paleozoic and lower Carboniferous flora of India. Origin and relationships of cycads, bennettites, ginkgos and glossopterids. Distribution of Glossopteris flora in time and space,
3. Brief concept of mass extinction: evidence in the geological record: plants versus animals; floral changes across the Cretaceous – Tertiary boundary.
4. Palaeopalynology of peat, lignite and coal. Artificial classification of spore.
5. Different aspects of palynology and their applications.

VIII. TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. History and Recent trends in classification.
2. Phenetic versus cladistics; APG System.
3. Concise accounts of the phylogeny of Basal Angiosperms, Magnoliids, Eudicots , Core eudicots.
3. Traditional knowledge: Ethnobotanical resources in India; documentation and utilization of ethnic knowledge. Traditional methods of conservation; sacred groves.
4. Flora and vegetation of Eastern Himalaya.
5. Forest Resources of North Bengal.

COURSE TYPE: PRACTICAL (P)

COURSE CODE: BOTA-CP-122

Credit: 4 **Full Marks: 100** **Total working hours: 192**

*ELECTIVE SPECIAL PAPER PRACTICAL

I. GENETICS AND BIOINFORMATICS

1. Plant DNA isolation and its quantification by UV –Spectrophotometer.
2. Preparation of "Cot-curve" from isolated DNA.
3. Restriction enzyme digestion of genomic DNA and agarose gel electrophoresis and visualization on UV -transillumination after staining by Ethidium bromide.
4. PCR and multiple arbitrary amplicon profiling.
5. Basic techniques of plant tissue culture and regeneration of plantlets.
6. Sequence analysis software and accessing biological data.
7. Gramene web-based genomic data analysis for marker trait association analysis.
8. Nucleic acid and protein sequence analysis, Phylogenetic analysis.
9. Basic techniques of molecular modelling.

II. MICROBIOLOGY

1. Study of physiological and biochemical activities of bacteria (hydrolysis of starch, lipid, protein and urea; degradation of cellulose and pectin; catalase; β-galactosidase; nitrate reduction; Voges-Proskauer reaction; indole production; liquefaction of gelatin; citrate utilization; fermentation/oxidation of sugars).
2. To assess the quality of milk by methyline blue reduction test.
3. Study of bacterial growth curve and determination of generation time.
4. To determine the effect of pH and temperature on microbial growth.
5. Isolation of bacterial genomic and plasmid DNA.
6. Study of fermentors and bioreactors (through photographs/slides/field visit).
7. Assay of antibiotics using tube dilution, well diffusion and agar dilution methods.
8. Detection and enumeration of indicator and index organisms for foodborne pathogenesis.

III. MOLECULAR PLANT PATHOLOGY AND FUNGAL BIOTECHNOLOGY

1. Isolation of plant DNA, fungal/bacterial/viral DNA, and quantification by uv-spectro photometer.
2. Separation of DNA by agarose gel electrophoresis.
3. Restriction endonuclease digestion of fungal/plant DNA.
4. DNA blot hybridization.
5. Polymerase Chain Reaction.
6. Extraction and bioassay of phytoalexin from plant tissue following induction by biotic/abiotic stress.
7. Partial purification of antifungal compounds by TLC and UV spectrophotometric analysis.
8. SDS-PAGE analysis of defense proteins.
9. Coulumn chromatographic separation of polyphenols/proteins.
10. Extraction and assay of defense enzymes.
11. Immunological characterization of defense proteins.
12. Preparation and purification of fungal/plant antigens.
13. Production of polyclonal antibody and purification of IgG.
14. Immunodiffusion, Immunoelectrophoresis, indirect ELISA.
15. Dot blot and Western blot for detection of plant pathogen.
16. Indirect-Immunofluorescence and fluorescent microscopy.

IV. PLANT BIOCHEMISTRY

1. Isolation of chloroplast and determination of Hill activity.
2. Protein extraction, precipitation by salting out, desalting by dialysis.
3. Protein purification by gel filtration/ ion exchange column.
4. SDS-PAGE analysis of the proteins and determination of molecular weights.
5. Assay of antioxidative enzyme (peroxidase/ catalase) activities following abiotic stresses.
6. Isozyme analysis by PAGE.
7. Separation of pigments by TLC and their identification.
8. Genomic DNA extraction from plants, quantification and gel electrophoresis.
9. Extraction, estimation and UV-spectral analysis of carotene and lycopene pigments.
10. Separation and detection of secondary metabolites through TLC.

V. PLANT GENETICS AND MOLECULAR BREEDING

1. Plant genomic DNA and fractionation on 1% agarose gel electrophoresis and visualization on UV-Trans-illuminator after staining by ethidium bromide.
2. Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material.
3. Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records.
4. Molecular markers: SSR profiling in crop plant Rice, Allelic variation through SNP analysis.
5. Analysis of morphological and molecular diversity in different cultivars/varieties of a crop plant including Rice.
6. QTL mapping (Theoretical using available data) using softwares like MAPMAKER, POWERMARKER, QTL-Cartographer.

7. Gene specific PCR amplification for trait analysis in breeding lines
8. DNA sequence analysis of Whole genome sequence- Model crop Rice.
9. Gramene web-based genomic data analysis for marker trait association analysis
10. Nucleic acid and protein sequence alignment for phylogenetic analysis.
11. Divergence of Codon uses in Model plant Rice using CodonW software.

VI. PLANT PHYSIOLOGY AND PHARMACOGNOSY

1. Assay of different Peroxidases enzyme activities following abiotic stresses.
2. Extraction, estimation and UV-spectral analysis of carotene and lycopene pigments.
3. Solvent extraction of plant metabolites through Soxhelation and refluxing and determination of extractive values
4. Determination of Fluorescence and ash value of powdered drugs.
5. Determination of free radical scavenging (DPPH and $ABTS^{+}$) activities of plant extracts.
6. Determination of superoxide scavenging activity of an extract.
7. Measurement of lipid peroxidation.
8. Qualitative phytochemical analysis of powdered drug.
9. Determination of metal chelating activity of plant drug.
10. Separation and detection of flavonoids through TLC and demonstration of chemical fingerprint under UV light.
11. Isolation of caffeine from tea and UV spectral analysis for determining the purity.
12. Isolation, purification and identification of *Solanum* alkaloids.

VII. PTERIDOLOGY, PALAEOBOTANY AND PALYNOLOGY

1. Studies of morphological, anatomical and reproductive structure of different groups of fern allies and ferns.
2. Comparative studies of scales on rhizome and rachis, epidermal features--trichomes hair and stomata of fronds of pteridophyte.
3. Meiotic studies of different ferns from developing sporangium.
4. Culture of fern gametophytes on suitable medium.
5. Study of different types of spores through acetolysis method.
6. Studies of tracheid's and vessels through maceration process.
7. Antifungal and antimicrobial activities of plant extract from different plant parts.
8. Studies of different types of mega and micro fossils from prepared specimen.

VIII. TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. Seasonal collection of local flora, processing, Herbarium management.
2. Phenology of some common weeds.
3. Seed, endosperm, embryo and seedling morphology.
4. Identification of plants by matching.
5. Working out of different angiospermic plants (fresh and dry), their identifications using literature and preparation of artificial keys.
6. Phytosociological studies; Biological Spectrum; Determination of Diversity Indices (Shannon-Wiener, Species Richness & β-diversity).
7. Use of GPS and demonstration on the use of at least one remote-sensing software

8. Familiarity with Taxonomic Literature (e.g. Index Kewensis, Wall-Cat., Icones, Bibliographies, Dictionaries, Keys, Floras, etc.).
9. Preparation of temporary and permanent pollen slides, description of common palynomorphs, preparation of identification keys.
10. Variation of characters - influence of ecological factors.
11. Ethnobotanical survey in a forest village/ village market.
12. Use of Electrophoresis, PCR, HPLC and other instruments useful in molecular taxonomy.
13. Basic techniques of micropropagation.
14. Identification of secondary metabolites and pigments.

COURSE CODE: BOTA-CT-123		
Credit: 2	**Full Marks: 50**	**Total working hours: 96**

DISSERTATION WORK

Dissertation work: Topics to be provided by the respective 'Elective Special Paper' teachers.

SUGGESTED READINGS

BIOSTATISTICS

1. Fundamentals of Biometry – L.N.Balaam
2. Fundamentals of Biostatistics – I.A. Khan and A.Khanum,Ukaaz Publications
3. Principles of Biometry- C.M.Woolf
4. Statistical Methods – G.W.Snedecor and W.G.Cochran

BRYOLOGY

1. Bryophyta - N.S.Parihar , Central Book Depot, Allahabad
2. Bryophye Ecology – A.J.E.Smith (Ed)
3. Bryophytes – P.Puri, Atma Ram & Sons Publishers, N.Delhi
4. Cryptogamic Botany, Vol.II – G.M.Smith
5. Liverworts of the Western Himalayas and Punjab Plain – S.R.Kashyap

CYTOLOGY AND GENETICS

1. Genetics : PJ Russell. Benjamin Cummings Pub. Inc. USA.
2. Principles of Genetics: Snustad and Simmons, John Wiley and Sons, USA
3. Concepts of Genetics: Klug and Cummings, Pearson Education, USA
4. Genome 3: T.A. Brown, Pearson Education, USA
5. Principles of Gene Manipulation and Genomics: Primrose and Twyman, Blackwell Scientific, Oxford.
6. Plant chromosome: Analysis; Manipulation and Engineering: Sharma & Sharma, Harwort Academic Pub. Australia
7. The Science of Genetics: Sauders College Publishing, Fort Worth, USA
8. Genetics: Principles and Analysis, Hartl and Jones, EW Jones & Bartlettt Pub, USA.
9. Gene IX: Lewin, B. Oxford University Press, USA.
10. Essential Genes, Lewin, B. Pearson Education.

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