Department of Botany

Faculty of Science

Course Work for Ph. D. Botany Students

Every student admitted in Botany for the Ph. D. program will be required to pass a course work of 16 credits. The course work has been divided into three papers. Paper-I (4 credits) is compulsory for all Ph.D. students. Paper-II (6-credits) is discipline-specific course and Paper-III (6 credits) is research theme- specific course.

Course Nature	Course Core	**Core Courses**	Credit
Compulsory Course			
Compulsory Course	BTHR 601	Research Methodology	04
		Credits	04
Discipline Specific Compulsory Course			
Discipline Specific Compulsory Course	BTHC 602	Instrumentation and Techniques in Plant Sciences and Identification and quantification of biomolecules	06
		Credits	06
Open Elective Course (Any one of the followings)			
Research Theme-Elective Courses	BTHE 603A	Advances in Phycology	06
	BTHE 603B	Advance in Mycology and Plant Pathology and plant fossil study/Paleobotany	
	BTHE 603C	Advance in Ecology	
	BTHE 603D	Advances in Plant Molecular Biology and Biotechnology	
	BTHE 603E	Evolutionary trends in plant Kingdome	
	BTHE 603F	Genetic concept in plants	
	BTHE 603G	Advance Plant Physiology and Biochemistry	
		Credits	06
		Total Credits	16

Research Methodology (Paper-1)

Code- BTHR 601 Credits-04

Learning Objectives:

To provide knowledge about research ethics among research students.
Enabling students for collection of data and interpret the result.

Outcomes:

After pre-Ph.D. course students will be aware about ethics of research field and can correlate science, technology and research ethics. They will be efficient in data representation and conceptualization and importance of Communication in Science.

1. Ethics in Science

1. Science and ethics; science as the social, cultural and human pursuit.
2. Ethical theory and applications.
3. Interrelationships of science with technology and delivery.
4. The source of ethical issues in science: examples from different disciplines.
   e.g. biotechnology, medical sciences, environmental issues, space research, energy, food security etc.
5. Social and moral responsibilities of scientists and activists.
6. Ethical issues in science research and reporting: objectivity and integrity, the problem of plagiarism and related issues, international norms and standards.
7. Scientific temper and virtues; expectations from scientific community.
8. Desired temper of scientists: truthfulness, simplicity, humility, open mindedness; attitude of service towards social and human well-being.

Suggested Readings:

1. David B. Resnik, 1998, The Ethics of Science: An Introduction. Routledge publisher. USA.
2. Callahan D. & Bok S., 1996, Ethics Teaching in Higher Education. Plenum Press. New York, USA.
3. Kapur J.N., 1996, Ethical Values for Ecellence in Education and Science. Wishwa Prakashan, New Delhi.
4. Tripathi A.N., 2008, Human Values. New Age International Publishers. New Delhi.

2. Methods of Research and Good Laboratory Practices

Methods of research:

1. Hypothesis: Literature Survey, defining the question and formulating hypothesis/ hypotheses

2. Methods: Collection of research data, tabulating and cataloging. Sampling and methods of data analysis
3. Record keeping and analysis: Generation of data, interpreting results/ data and drawing conclusions
4. Laboratory Safety measures: Handling of Radiation, Bio-hazardous and other toxic experimental materials
5. Facilitation of Scientific deliberations among students and faculty

Good laboratory practices:

1. Recording and storage/ retention of recorded materials
2. Maintenance of equipment, proper storage and disposal of hazardous materials (chemical & biological)
3. Management and user responsibilities in proper utilization of the facilities

Suggested Readings:

1. Jürg P. Seiler Good laboratory practice: the why and the how 2005. http://uqu.edu.sa/files2/tiny_mce/plugins/filemanager/files/4281709/good_laboratory_practice:_the_why_and_the_how.pdf

2. Good Laboratory Practice. http://en.wikipedia.org/wiki/Good_Laboratory_Practice

3. What is scientific method? http://www.experiment-resources.com/

4. Research methodology resources. http://edutechwiki.unige.ch/en/Research_methodology_resources

5. Overview of research methods. www.answer.com/ topic/ overview_of_-_research_-_methods

3. *Science Communication*

1. Nature and importance of Communication in Science
2. Preparation of manuscripts: review articles, research papers, books, monograms, research projects; review of manuscripts
3. Survey of literature, and presentation of data
4. Preparation of power point presentation
5. Popularization of Science
6. Socio – Legal issues: Originality, Integrity, IPR, Patents, Plagiarism

Suggested Readings:

1. A. Wilson: Handbook of Science Communication, 1998, Institute of Physics Publishing, Bristol, Philadelphia.
2. Science Communication: Theory & Practice; Stocklmayer, Gore MM, Bryant C (Eds.), 2002, Springer.
3. Laszis P: Communicating Science: A practical Guide, 2006, Springer.

Discipline specific Compulsory Course- (Paper II)

Code- BTHC 602 **Credits-06**

Learning Objectives:

To provide knowledge about Principles and Application of various instruments and Techniques used in plant sciences.

Outcomes:

After pre-Ph.D. course students will be skilled to handle various types of instruments used in research work and will be knowledgeable in technique of biosciences.

Unit I: Instrumentation

Principles and Application of Various instruments

- Microscopes: phase contrast, differential image control, fluorescence, confocal, scanning and transmission electron microscopes.
- Spectrophotometer: UV-Visible, Mass Spectrophotometer, ICP-MS (Inductively coupled plasma mass spectrophotometer), AAS (Atomic Absorption Spectroscopy) and fluorescencespectrophotometers

Unit II: Techniques in Plant Sciences and Identification and quantification of biomolecules

- Tissue culture techniques: Media preparation, sterilization, *in vitro* regeneration
- Microbial culture techniques: Sterilization, culture media, types of cultures- batch and continuous, culture preservation.
- Genomics: Isolation of genomic and plasmid DNA, Gel Electrophoresis, PCR, Genome sequencing
- Chromatography
- Centrifugation
- Bioinformatics: Basic concepts and applications.

Suggested Readings for Unit 1 and 2:

- J.M. Miller, 2005, Chromatography - Concepts and Contrasts. John Wiley & Sons, New Jersey, USA.
- R.L. Grab and E. F. Barry, 2004. Modern Practice of Gas Chromatography fourth edition). John Wiley & Sons, New Jersey, USA.
- W.J. Ough and I.W. Wainer, 1995. High Performance Liquid Chromatography- Fundamental Principles and Practices. Blackie Academic & Professional, Glasgow.

Scotland.

- B.D. Hames (ed.) 2002, Gel Electrophoresis of Protein- A Practical Approach. Oxford University Press Inc., New York, USA.
- K. Wilson and J. Walker (ed.). 2010, Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.
- F.S. Parker, 1983, Applications of Infrared, Raman and Resonance Raman Spectroscopy in Biochemistry. Plenum Press, New York, USA.
- J.B. Harborne, 1998, Phytochemical Methods-A Guide to Modern Techniques of Plant Analysis. Chapman & Hall, London, U.K.
- S. Sadasivam and A. Manickam, 2005, Biochemical Methods. New Age International Private Ltd., New Delhi.
- D. Heard (ed.) 2006, Analytical Techniques for Atmospheric Measurements. Blackwell Publishing Ltd., UK.
- G.K. Agrawal, R. Rakwal, (Ed.) 2008, Plant Proteomics- Technologies, Strategies and Application. John Wiley & Sons, New York, USA.
- M. Radojević and V.N. Bashkin, 1999, Practical Environmental Analysis. Royal Society of Chemistry, Cambridge, UK.
- American Public Health Association (APHA). 1998, Standard Methods for the Examination of Water and Wastewater 19th edition. Washington, D.C.

Research Theme Elective Courses (Paper –III Optional)

Course code-BTHE 603 **Credits-06**

Learning Objectives:

To make them efficient about principles and application of various scientific research fields.

Outcomes:

After pre-Ph.D. course students will become proficient in recent approaches in various research areas of biosciences.

CODE: BTHE 603 A: Advances in Phycology

1. Salient features of cyanobacteria and algae: Origin, distribution in nature, and evolutionary tendencies.
2. Taxonomic advancement in various groups of algae and their molecular phylogeny
3. Regulation of cellular differentiation in cyanobacteria under symbiotic and asymbioticstates.
4. Nitrogen fixation in cyanobacteria: Structure and function of nitrogenase enzyme complex, biochemistry of nitrogen fixation, physiological and genetic regulation of nitrogen fixation and its significance in nitrogen cycle.
5. Features of model organisms from cyanobacteria (*Synechocystis* sp. PCC 6803, *Nostoc* sp. PCC 7120 and algae (*Chlamydomonas reinhardtii)*. Retrieval of data and their bioinformatics analysis.
6. Cyanobacterial phycobiliproteins and photoprotective compounds: Potential applicationin Biomedical Sciences.
7. Metabolic engineering in microalgae: Algal cell as a bio-factory, Concept of transcriptome and metabolome.
8. Algae in environmental sustainability: Role of algae in CO_2 sequestration and bioremediation of pesticides and heavy metals.
9. Algae in industry: Trends and future prospects.

CODE: BTHE 603 B: Advance in Mycology and Plant Pathology and plant fossil study/Paleobotany

1. Introduction: Historical and developmental aspects of mycology and plant pathology.
2. Structural diversity of Fungi and Mycorrizae and their role in ecosystem.
3. Molecular systematics of Fungi; modern tools for identification.
4. Useful fungi and their metabolites of industrial importance.

5. Mode of infection and role of enzymes and toxins in plant diseases.
6. Plant-microbes interactions: molecular basis of plant-fungal, and bacterial pathogen interactions, virulence factor, host resistance and plant immunity; pattern triggered andeffector triggered immunity, ISR and SAR.
7. Post-harvest pathology: Fungal deterioration of food commodities, mycotoxins and healthhazards, control measures.
8. Major fungal diseases and their impact on society; late blight of potato, rust disease, panama disease, wilt disease, Dutch elm disease, chestnut blight, phyllody of sesame, leafcurl of papaya etc.
9. Yeast as a eukaryotic model organism: mutant creation and characterization, yeast vectors, yeast two hybrid system, genetic and physical interactions studies in yeast, SGA analysis, functional genomics and proteomics studies in yeast.
10. Fossil plants, qualitative and quantitative study, impacts on Phytogeography, Ecology, Paleoclimate/ Paleoenvironment, Assessment of Environmental factors e.g. temperature,humidity and rainfall etc., fossil fuels.
11. Application of molecular biology in control of plant diseases; transgenic approach for crop protection, engineering chemicals that elicit defense response to plants.
12. Integrated Disease Management: fungi as bio-control agents and their mechanism.

CODE: BTHE 603 C: Advances in Ecology

1. Biodiversity Assessment and Impacts: Assessment of biodiversity, Degradation and lossof biodiversity, Conservation and management of biodiversity.
2. Riverine Ecology: River continuum concept, eutrophy and concept of nutrient limitation,River ecosystem and resilience.
3. Ecology of Plant Invasion: Invasion, invasion processes, hypothesis regarding invasion, success of invaders, Species invasiveness, invasive species in India, Management of invasive species.
4. Restoration Ecology: Concept and strategies of ecological restoration, Ecology of disturbed ecosystems, Degradation and restoration of natural ecosystems.
5. Management of Soil Contamination: Spatial and temporal trends of soil contaminants,Risk assessment, Current remediation approaches.
6. Water Pollution and Management Strategies: Emerging water pollutants, Water qualitycharacterization and monitoring, Innovative management strategies.
7. Air Pollution and Climate Change: Global warming impacts on various ecosystems,Mitigation measures on global warming, Mechanism of toxicity of air pollution in plants.
8. Bioremediation: Bioremediation of heavy metal toxicity in environment, Microbialdegradation of solid wastes.
9. Environmental omics in relation to: Current status and future perspectives. Soil fertilityand stability, Removal of pollutants.

CODE: BTHE 603 D: Advances in Plant Molecular Biology and Biotechnology

1. Introduction to various model plants and their related databases: *Arabidopsis thaliana*, *Oryza sativa*, *Populus trichocarpa* and *Physcomitrium patens*.

2. Plant developmental biology: Cell specification, flowering, molecular basis of differentiation and organogenesis in the flowering plants.
3. Genome, epigenome and environment: Emerging concepts on the role of the environment in genome and epigenome changes, evolution in plants, and establishment and evolution of heterochromatin.
4. Plant immune signalling: Plant immune system, Origin and evolution of plant Immune System, Microbial patterns and plant pattern recognition, Cell surface PRRS, Dynamic regulation of PRRs, PAMP-triggered immunity (PTI), Effector-triggered immunity (ETI),Plant defence priming and Transgenerational Immune Priming (TGIP).
5. Tools and concepts to improve plants and their products: r DNA technology: Restriction enzymes and nucleic acid modifying enzymes, Vectors for gene cloning, methods for selection and screening of recombinant clones; Transformation methods, Isolation of gene of interest - direct selection, construction and screening of genomic and cDNA libraries; Transgenic crops: Bt- crops, golden rice, Flavr Savr tomato, Resistance to biotic/abiotic stresses and quality improvement.
6. Molecular breeding and Cytogenetics: Molecular markers, Marker-assisted breeding (MAB) and molecular-assisted selection (MAS); Post-genomic tools for genetic enhancement of germplasm, Karyotyping, Breeding through chromosome manipulation.
7. Genome modification: Strategies for modifying genomes using Agrobacterium, Zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs),and CRISPR/Cas systems.
8. Bioinformatics and IPR related issues: Software's and databases related to *in silico* expression, *cis*-regulatory elements (CREs) and Orthologs identification and evolutionary divergence analysis, Cognate TF analysis. IPR-related issues: trademarks, copy rights, patents, geographical indicators.

CODE: BTHE 603 E: Evolutionary trends in plant Kingdom

1. *Evolutionary trend in algae*

Primary, secondary, tertiary and serial secondary symbiosis,
Metabolite antiporter and biochemical pathway, Genetic integration and reduction

2. *Evolution of bryophytes*

Morphological characteristics of bryophytes, affinities with other organism, various modeof reproduction, theories of evolution

3. *Evolutionary trend in sporophytes*

Seeds and Pollen as an Evolutionary Adaptation to Dry Land, Flowers and Fruits as anEvolutionary Adaptation,

4. *Basal Angiosperms*

Amborella, Nymphaeales, Austrobaileyales, Mesangiospermae, Angiospermic fossils

CODE: BTHE 603 F: Genetic concept in plants

1. *Genome- Basic concept and molecular organization*

Chromosome structure, nucleosome, solenoid and packaging of DNA, molecular

organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, karyotype analysis, banding patterns, karyotype specialized chromosomes- polytene chromosomes, lampbrush chromosomes, B-chromosomes, Nuclear DNA content, C-value paradox, multigene families and their evolution, Structure and Properties of Nucleic acids: Structure, Chemical, Physical, Spectroscopic and thermal properties of nucleic acids. Dissociation and re-association kinetics of DNA, Cot-curves, Cot½values and its significance. Unique, moderately repetitive and highly repetitive DNA, conformation of nucleic acids. (A, B, Z DNA, t-RNA, micro RNA), DNA sequencing and amplification, molecular genetic maps, genome projects, In situ hybridization to locate transcripts in cells FISH, GISH, Computer assisted chromosome analysis, chromosome micro dissection and micro cloning, flow cytometry and confocal microscopy in karyotype analysis. Genetic Fine Structure, cis-trans test, Fine structure analysis in eukaryotes, Allele concept, multiple alleles, isoalleles, pseudoalleles

2. *Inheritance Genetics*

Principles of Mendelian inheritance and Interaction of genes: Introduction to pre Mendelian, Mendelian and Post Mendelian genetics. Complementary, epistasis, inhibitory, Duplicate, Polymeric, Lethal and additive interaction ofgenes.

Cytoplasmic inheritance:- Cytoplasmic inheritance involving chloroplast (*Mirabilis jalapa*, *Zea mays*) and Mitochondria (petite yeasts and cytoplasmic male sterility in higher plants), mitochondrial and chloroplast genomes, interaction between nuclear and cytoplasmic genes.(Rubisco and Cytochrome oxidase)

Quantitative Inheritance: Qualitative and Quantitative traits, Continuous variation, Inheritance of quantitative traits, (corolla length in Nicotiana, coblength in Zea mays), multiple factors hypothesis and heritability.

Population genetics:- Gene and genotype frequencies, Hardy-Weinberg law, Factors affecting Hardy-Weinberge quilibrium (selection, mutation, migration and genetic drift)

3. *Cyto-genetics and variation*

Structural changes in chromosomes: Origin, meiosis and breeding behavior of duplication, deficiency, inversion and translocation heterozygotes. Cytological consequences of crossing over in Inversion and translocation heterozygotes Genetics of structural heterozygotes, complex translocation heterozygotes, Robertsonian translocations, B-A translocations

Numerical alterations in chromosomes: Origin, occurrence and meiosis of haploids, aneuploids and euploids. Origin and production of autopolyploids, chromosome and chromatid separation, allopolyploids. Induction and characterization of trisomics and monosomics. Transmission of trisomics and monosomics.

Recombination and gene map :- Concept of Linkage, Types and Applications, Concept and Types of Recombination, Molecular mechanism of recombination, site specific recombination estimation of recombination percentages and map distances, Gene

mapping in Fungi using ordered and unordered tetrads of Neurospora, Three point test crosses and estimation of linkage distances in plants.Gene maps and physical maps.

Mutation and DNA repair mechanism- Spontaneous and induced mutation, physical and chemical mutagens, molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, site directed mutageneis, DNA damage and repairmechanism- Types of DNA damage, enzymes involved in repair of DNA, excision repair, recombination repair and mismatch repair systems.

4. *Molecular Genetics*

Cell Cycle and apoptosis: Control mechanisms, role of cyclins and cyclin dependent kinases, mechanism of programmed cell death, Genetic Code

Gene Structure: Organization and Structure of prokaryotic and eukaryotic genes; structure and role of promoters, exons, introns, terminators and enhancers
DNA Replication :- Mechanism of prokaryotic and eukaryotic DNA replication, replication apparatus, Origins of replication, priming and DNA polymerases.
Transcription: RNA polymerases and theirrole, Transcription apparatus, Transcription in prokaryotes and eukaryotes, Initiation, elongation and termination, RNA processing, reverse transcription and cDNA synthesis, Ribonucleo-proteins,Structure of mRNA.
Regulation of Transcription in prokaryotes and eukaryotes: Operon concept (Lac, Tryptophan, Arabinose) positive and negative regulation of prokaryotic genes, eukaryotic transcription factor, transcriptional and translational control

CODE: BTHE 603 G: Advance Plant Physiology and Biochemistry

Lipids and Amino Acids Biosynthesis: Lipids- structural and storage lipids and their functions; Amino acid metabolism in plants. Secondary Metabolites: Secondary metabolites-Role of natural products in plant defence, pharmaceuticals and cosmetics; Phytoremediation.
Study of parameters related to Photosynthesis and Respiration. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity partitioning efficiency and harvest index. Crop growth models-empirical models testingand yield prediction.
Stress physiology: Biotic and Abiotic stress; Physiological and Biochemical responses of plants to environmental stress; Plant responses to salinity and chilling stress; Abiotic stress and secondary metabolite production. Stress Proteins in plants- HSP, Osmotin, PR, BSIPS, salt-, cold- and UV light- induced proteins. Development of transgenic plants for abiotic stress tolerance.
Hormones & Signal Transduction: Hormonal regulation of plant growth and development, signal Transduction, Role of PGR in agriculture and horticulture. Status of Plant Physiology Research in India.
Enzyme Assays, Chemical and enzymatic methods of carbohydrate analysis, separation

and identification of carbohydrates, lipids and amino acids mixtures; principle and methods of protein separation techniques, basic of chromatography-gel filtration, Ion exchange, affinity, HPLC,FPLC, Electrophoresis- SDS.

Suggested Readings:

1. L. Taiz and E. Zeiger (2002) Plant Physiology (Second Edition) Sinauer Associates IncPublishers Sunder lands, Massachusetts
2. H.W. Heldt (1997) Plant Biochemistry and Molecular Biology Oxford University Press
3. W.G. Hopkins (1985) Introduction to Plant Physiology John Wiley and Sons, Inc.New York
4. Methods in Enzymology Colowick and Caplan Academne Press, New York
5. Coombs, Hall, Long and Scurlik (1985) Techniques in Bioproductivity and Photosynthesis,Pergmon Press, Oxford
6. Hall, Scurlik, Bolhar, NordenKamf, Leagood and Long (1993) Photosynthesis and production in a Changing Environment. A Field and Laboratory Manual, Chapman and Hall Publication
7. Buchnan, B.B., Gruissem, W. and Jones, R.L. (2000) Biochemistry and Molecular Biology of Plants. I . K. International Pvt . Ltd., New Delhi.