RAMAKRISHNA MISSION VIVEKANANDA EDUCATIONAL & RESEARCH INSTITUTE

(Declared by Government of India under section 3 of UGC Act, 1956)

P.O. Belur Math, District- Howrah, West Bengal: 711202

INTEGRATED RURAL DEVELOPMENT & MANAGEMENT (IRDM) FACULTY CENTRE

at

Ramakrishna Mission Ashrama, Narendrapur, Kolkata: 700 103

Two year M. Sc. (Ag.) in 'Genetics and Plant Breeding'

PROPOSED COURSE CONTENT (with effect from academic year 2018-19)

Semester-I

GPB 101: Principles of Genetics (2+1) credits
GPB 102: Principles of Cytogenetics (2+1) credits
GPB 103: Principles of Plant Breeding (2+1) credits
ABT 104: Biostatistics –I (2+1) credits
GPB 105: Principles of Seed Production (3+0) credits
ABT 107: Spiritual and Cultural Heritage of India-I (2+0) credits
Total: 13+ 4 = 17

Semester-II

GPB 201: Breeding of Field Crops-I (2+1) credits
GPB 202: Principles of Quantitative Genetics (2+1) credits
GPB 203: Analytical techniques & instrumental methods in soil & plant analysis (1+2) credits
GPB 204: Heterosis Breeding (2+1) credits
ABT 205: Genetic Engineering (2+0) credits
ABT 203: Biostatistics –II (1+1) credits
ABT 208: Spiritual and Cultural Heritage of India-II (2+0) credits
GPB 205: Seminar-I (0+1) credit
ABT 206: Molecular Tools and Techniques (0+2) credits
Total: 12+ 9 = 21

Semester-III

ABT 105: Molecular Biology (2+0) credits
GPB 301: Breeding of Field Crops-II (2+0) credits
ABT 303: Molecular Breeding (2+1) credits
GPB 302: Plant Genetic Resources and their utilization (2+1) credits
GPB 303: Breeding for Stress Resistance (2+1) credits
GPB 304: Mutagenesis and mutation breeding (2+1) credits
ABT 106: Plant Tissue Culture (2+1) Credits
GPB 305: Seminar –II: Proposed Plan of Dissertation Work (0+1) credits
Total: 14+5 = 19

Semester-IV

ABT 201: Fundamentals of Crop Protection (3+2) credits
GPB 401: Seminar-III (0+1) credits
GPB 402: Dissertation work (0+24) credits
Total: 3+27 = 30

Optional/ Special Papers

GPB 501: Introduction To Bioinformatics (3+1) credits

GPB 502 : Diversity Analysis (2+1) credits

GPB 601: Breeding For Crop Quality Traits (2+1) credits

GPB 602 : Genomics and Proteomics (2+0) credits

Semester-I [Total: 13 (T) + 4 (P) = 17 credits/ 306 hours]

GPB 101: Principles of Genetics (2+1) Credits

Theory: 2 Credits/ 36 hours

1. Beginning of genetics; Cell structure and cell division; Early concepts of inheritance. Mendel's laws. Discussion on Mendel's paper. Chromosomal theory of inheritance. **4 hours**
2. Multiple alleles, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes. Somatic cell genetics, Extra chromosomal inheritance. **6 hours**
3. Population Genetics: Mendelian population – Random mating population. Frequencies of genes and genotypes - Causes of change. Hardy-Weinberg equilibrium. **2 hours**
4. Structural and numerical changes in chromosomes. Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis. **6 hours**
5. Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters. **4 hours**
6. Regulation of gene activity in prokaryotes and eukaryotes. Molecular chaperones and gene expression. RNA editing. **4 hours**
7. Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR-based cloning, positional cloning; Nucleic acid hybridization and immuno-chemical detection; DNA sequencing; DNA restriction and modification, Gene silencing: Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs). **4 hours**
8. Genomics and proteomics; Functional and pharmacogenomics; Metagenomics. **2 hours**
9. Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. **2 hours**
10. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics. **2 hours**

Practical: 1 Credit/ 18 hours

1. Laboratory exercises in probability and chi-square. **2 hours**
2. Demonstration of genetic principles using laboratory organisms. **4 hours**
3. Chromosome mapping using three point test cross; Tetrad analysis. **4 hours**
4. DNA extraction and PCR amplification. **4 hours**
5. Extraction of proteins and isozymes. Use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations. **2 hours**
6. Detection of transgenes in the exposed plant material; Visit to transgenic glasshouse and learning the practical considerations. **2 hours**

GPB 102: Principles of Cytogenetics (2+1) Credits

Theory: 2 Credits/ 36 hours

1. Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes. **4 hours**
2. Chromosomal theory of inheritance: Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over-recombination models, cytological basis. Variation in chromosome structure, Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications. **8 hours**
3. Structural and Numerical variations of chromosomes and their implications - Symbols and

terminologies for chromosome numbers - euploidy - haploids, diploids and polyploids; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes. **8 hours**

4. Inter-varietal chromosome substitutions. Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids – Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization; Apomixis - Evolutionary and genetic problems in crops with apomixes. **6 hours**

5. Reversion of autopolyploids to diploids; Genome mapping in polyploids -Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica). Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids – Bridge species. **6 hours**

6. Fertilization barriers in crop plants at pre-and postfertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding. **4 hours**

Practical: 1 Credit/ 18 hours

1. Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. Microscopy: various types of microscopes, Observing sections of specimen using Electron microscope. **2 hours**

2. Preparing specimen for observation: Fixative preparation and fixing specimen for light microscopy. Studies on the course of mitosis in rice, wheat, onion and *Aloe vera.* **4 hours**

3. Studies on the course of meiosis in cereals, pulses, oilseeds and forage crops. **4 hours**

4. Using micrometers and studying the pollen grain size in various crops. Various methods of staining and preparation of temporary and permanent slides. Pollen germination *in vivo* and *in vitro.* **2 hours**

5. Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level; Identification of polyploids in different crops. Induction and identification of haploids; Anther culture and Ovule culture. **2 hours**

6. Morphological observations on synthesized autopolyploids. Morphological observations on allopolyploids; Morphological observations on aneuploids. **2 hours**

7. Cytogenetic analysis of interspecific and intergeneric crosses; Various ploidy levels due to somaclonal variation; Polyploidy in ornamental crops. Fluorescent *in situ* hybridization (FISH) and Genome *in situ* hybridization (GISH). **2 hours**

GPB 103: Principles of Plant Breeding (2+1) Credits

Theory: 2 Credits/ 36 hours

1. History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding. Patterns of Evolution in Crop Plants - Centres of Origin-biodiversity and its significance. **2 hours**

2. Genetic basis of breeding self- and cross-pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding. Plant introduction and role of plant genetic resources in plant breeding. **6 hours**

3. Self-incompatibility and male sterility in crop plants and their commercial exploitation. **2 hours**

4. Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach). **8 hours**

5. Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites. Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds. **6 hours**

6. Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection. **2 hours**

7. Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding. **2 hours**

8. Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses. **4 hours**

9. Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights. **2 hours**

Practical: 1 Credit/ 18 hours

1. Floral biology in self and cross pollinated species, selfing and crossing techniques. **6 hours**

2. Selection methods in segregating populations and evaluation of breeding material. Analysis of variance (ANOVA); Estimation of heritability and genetic advance. **6 hours**

3. Maintenance of experimental records. **2 hours**

4. Learning techniques in hybrid seed production using male-sterility in field crops and visit to seed companies producing hybrid seeds. **4 hours**

ABT 104: Biostatistics –I (2+1) credits

Theory: 2 Credits/ 36 hours

1. Agricultural Statistics- Meaning and importance, its Characteristics. Analysis and interpretation of data: Data- Definition, types (Qualitative vs. Quantitative) Presenting quantitative Data- Graphical presentation (Bar diagram, Histogram, Frequency Polygon, Ogive, Pie chart etc.); Tabular presentation (Simple, Bivariate, Multivariate). **6 hours**

2. Measures of Central Tendency: Mean- definition, properties, advantage and disadvantages, use; Median- Definition, properties, advantage and disadvantages, use; Mode- Definition, properties, advantage and disadvantages, use. Interpretation and Conclusion. **4 hours**

3. Measures of Dispersion: Range, Mean deviation, Quartile deviation, Standard deviation, Variance etc: Deviation and use; Skewness and Kurtosis, Interpretation and Conclusion. **4 hours**

4. Correlation and regression: Definition, Simple correlation coefficients its properties, Rank correlation coefficients, Partial correlation coefficients, multiple correlation coefficients, Regression analysis, concepts of regression line and its utility, interpretation and conclusion. **6 hours**

5. Elementary concept of Normal Distribution, Binomial distribution and Poison distribution. **8 hours**

6. Hypothesis- Definitions, Types, Sources, Utility, and Characteristics of good hypothesis, Z-test, t-test, F-test, $\chi 2$ test: definition and application. **8 hours**

Practical: 1 Credit/ 18 hours

1. Graphical presentation (Bar diagram, Histogram, Frequency Polygon, Ogive, Pie chart etc.); Tabular presentation. **2 hours**

2. Practical on mean, median and mode. **4 hours**

3. Analysis of measures of dispersion and skewness and kurtosis. **4 hours**

4. Analysis of correlation and regression. **4 hours**

5. Study on Z-test, t-test, F-test, $\chi 2$ test. **2 hours**

6. Use of Computer in Research (Concepts only)- entry; Data Presentation and Analysis using appropriate Software: Statistical Packages. **2 hours**

GPB 105: Principles of Seed Production (3+0) credits

Theory: 3 Credits/ 54 hours

1. Seed as a basic input in agriculture, difference between seed and grain, concept of quality seed, quality control in seed production, role of high quality seed in crop production. **4 hours**

2. Classification of crop plants in relation to mode of reproduction and choice of methods of seed production. **4 hours**

3. Pollination mechanism in plant breeding and crop production. Ecology and dynamic of pollination, specificity of flowers and pollen, pollen dispersal, natural cross pollination rate, artificial control of out-crossing. **4 hours**

4. Concept of genetic purity of varieties, methods of maintenance of genetic purity, isolation distance, general concept of nucleus, breeder, foundation and certified seeds. **4 hours**

5. Concept of hybrid seed production – hand emasculation, and pollinations, detasselling, male sterility, gametocides and self incompatibility. **8 hours**

6. Factor affecting seed set – temperature, humidity, day length, wind velocity, duration of flowering, anthesis, pollen viability, stigma receptivity, nutrition and irrigation. **4 hours**

7. Agronomic management of seed production – selection of suitable agroclimatic region, seed plot, isolation of seed crops, preparation of land, soil types, selection of variety, seed treatment, time of planting, seed rate, method of sowing, depth of sowing, rouging, supplementary pollination, weed control, disease and insect control, nutrition, irrigation, time of harvest, seed drying and storage. **16 hours**

8. Production methods of propagules other than true seeds – cutting, layering, grafting, budding, productions of specialized vegetative structures like tubers, bulbs, rhizomes, suckers, runners, offsets, etc. **4 hours**

9. Seed orchards or plantations. Seed production of forest trees. Seed production system and management – systems of seed production in India, agencies, planning, organizing and managing seed production programme in India and abroad. Systems of release and notification of varieties for general cultivation. **6 hours**

ABT 107: Spiritual and Cultural Heritage of India-I (2+0) credits

Theory: 2 Credits/ 36 hours

1. Shanti Mantras and some selected vedic hymns-Shraddha Suktam, Sangha mantra etc. **2 hours**

2. Swami Vivekananda's Message to the Youth: It is youth who will transform this nation, Take up an ideal and give your whole life to it, Stand on your own feet, Awaken the spirit of 'Rajas' within you, Believe in yourself, Be bold and fearless, Expand your heart, Be open to learning from anyone, Develop a gigantic will. **10 hours**

3. Swami Vivekananda's Message to Reformers: Liberty is the first condition for growth, Affirm; Do not condemn, Don't lead but serve, Act with unselfish motives, create 'sanction' from the people, The Indian Nation will rise only when the self-esteem of the masses is raised, Real social reform will happen when the people learn to help themselves. **12 hours**

4. Swami Vivekananda's message to Educationists: manifest the infinite knowledge within, man-making education, strengthen faith and pride in ourselves as a nation, focus on character-building assimilation of ideas, enable the student to learn, enable individuals to find solutions to the challenges of life, give ideas and culture, develop the power of concentration. The condition necessary for the teacher, the taught and for effective transfer of learning. **12 hours**

Semester-II [Total: 12 (T) + 9 (P) = 21 credits/ 378 hours]

GPB 201: Breeding of Field Crops-I (2+1) credits

Theory: 2 Credits/ 36 hours

1. CEREALS

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives - yield, quality characters, biotic and abiotic stress resistance etc.

Pearl millet: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

Sorghum: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc. **16 hours**

2. PULSES

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

Moong bean: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them – emerging challenges at national and international level. **8 hours**

3. OILSEEDS

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress etc.

Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship. **6 hours**

4. FIBRE CROPS

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. **2 hours**

5. Distinguishing features of popular released varieties in Rice, Pearl millet, Maize, Sorghum, Pigeonpea, Urd bean, Moong bean, Cotton and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production. Maintenance Breeding and All India Co-ordinated System of testing and release of crop varieties and hybrids. **4 hours**

Practical: 1 Credit/ 18 hours

1. Floral biology – emasculation - pollination techniques of different crops. **2 hours**

2. Study of variation for yield and yield components - Trait based screening for stress resistance in

important crops– Use of descriptors of rice, maize, pulses and oilseeds for cataloguing Germplasm maintenance; Using Standard Evaluation System (SES) and descriptors, **6 hours**
3. Evaluating the germplasm of rice, moong bean, maize for yield, quality and resistance parameter. **6 hours**
4. Field and lab visit of the concerned crops **4 hours**

GPB 202: Principles of Quantitative Genetics (2+1) credits

Theory: 2 Credits/ 36 hours

1. Mendelian traits versus polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects. **6 hours**
2. Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance. **4 hours**
3. Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models - concepts of selection - heritability and genetic advance. **6 hours**
4. Generation mean analysis; Mating designs - Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for G x E analysis and stability parameters; AMMI analysis – principles and interpretation. **14 hours**
4. QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis. Association mapping, linkage disequllibrium. **6 hours**

Practical: 1 Credit/ 18 hours

1. Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis . **4 hours**
2. Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results. Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. **8 hours**
3. Line x tester analysis and interpretation of results - Estimation of heterosis: standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression. **2 hours**
4. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interaction , Models in stability analysis. **2 hours**
5. Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation. **2 hours**

GPB 203: Analytical techniques & instrumental methods in soil & plant analysis (1+2) credits

Theory: 1 Credit/ 18 hours

1. Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling. **2 hours**
2. Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and

potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils. **2 hours**

3. Principles of visible and ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods. **4 hours**

4. Determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity. **4 hours**

5. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods. **4 hours**

6. Determination of lime and gypsum requirement of soil. Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results. **2 hours**

Practical: 2 Credits/ 36 hours

1. Preparation of reagents, standard solutions, buffers and samples (soil, water, plants). Acid-base titration. Oxidation-reduction titration. **4 hours**

2. Determination of available nitrogen, phosphorus and potassium in soil. **8 hours**

3. Demonstration and hand-on practice for the analysis of organic compounds in soils and plants using UV-vis spectrophotometer assay, HPTLC fingerprint, GC-FID analysis and HPLC-DAD analysis. **6 hours**

4. Determination of cation exchange capacity from organic sample. Extraction of exchangeable cations (Ca, Mg, Na and K). **6 hours**

5. Determination of minerals and trace elements in soil and plants by Atomic Absorption Spectrophotometer. **8 hours**

6. Determination of $CaCO_3$ equivalent (lime and gypsum). Estimation of available (DTPA extractable) iron, manganese, copper and zinc in soil. **4 hours**

GPB 204: Heterosis Breeding (2+1) credits

Theory: 2 Credits/ 36 hours

1. Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops . **2 hours**

2. Pre-Mendelian and Post-Mendelian ideas: Genetic theories of heterosis. Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Evolutionary concepts of heterosis. **4 hours**

3. Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis - case studies. - Relationship between genetic distance and expression of heterosis case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis. **4 hours**

4. Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines-A, B and R lines - functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids. **8 hours**

5. Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line

hybrid. **8 hours**

6. Organellar heterosis and complementation. Creation of male sterility through genetic engineering and its exploitation in heterosis. **4 hours**

7. Heterosis breeding in wheat, rice, maize, pearl millet, sorghum and mustard, sunflower crops. **6 hours**

Practical: 1 Credit/ 18 hours

1. Selection indices and selection differential – Calculations and ineterpretations – Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources – Male sterile line creation in Rice and other crops. **4 hours**

2. Problems in creation of CGMS system; Ways of overcoming them – Male sterile line creation, diversification and restoration in Rice. **2 hours**

3. Estimation of heterotic parameters in self, cross and asexually propagated crops – Estimation from the various materials using heterosis parameters – Hybrid seed production in field crops specially Rice and Maize – an account on the released hybrids; their potential; Problems and ways of overcoming it; Hybrid breeding at national and international level; Opportunities ahead. **4 hours**

4. Evaluation of restorer, cytoplasmic sterile and partial restorer lines in Rice. **4 hours**

5. Evaluation of rice hybrid varieties developed at national level. **2 hours**

6. Study of some TGMS lines in Rice. **2 hours**

ABT 203: Biostatistics –II (1+1) credits

Theory: 1 Credit/ 18 hours

1. Sampling: Meaning and Significance, Types, different Sampling methods, Sampling errors and biases. **4 hours**

2. Design of Experiments: Definition, importance etc., Principles of design of experiments, Concepts of Uniformity trial and contour map. **2 hours**

3. Completely Randomized Design (CRD): Definition, model, Lay out, Analysis of Variance (ANOVA), Advantages and Disadvantages. **2 hours**

4. Randomized Block Design (RBD): Definition, model, Lay out, Analysis of Variance, Advantages and Disadvantages. **2 hours**

5. Latin Square Design (LSD): Definition, model, Lay out, Analysis of Variance, Advantages and Disadvantages. **2 hours**

6. Split Plot Design: Definition, model, Lay out, Analysis of Variance, Advantages and Disadvantages. **3 hours**

7. Factorial Design: Definition, model, Lay out, Analysis of Variance, Advantages and Disadvantages. **3 hours**

Practical: 1 Credit/ 18 hours

1. ANOVA of Completely Randomized Design (CRD). **2 hours**

2. ANOVA of Randomized Block Design (RBD). **2 hours**

3. ANOVA of Latin Square Design (LSD). **2 hours**

4. ANOVA of Split Plot Design. **4 hours**

5. ANOVA of Factorial Design. **4 hours**

6. Analysis of variance using appropriate Software: Statistical Packages. **4 hours**

ABT 205: Genetic Engineering (2+0) credits

Theory: 2 Credits/ 36 hours

1. Host restriction and modification system, Restriction enzymes and cutting of DNA. DNA ligase and ligation of DNA molecules, DNA modifying enzymes: Kinase, Alkaline phosphatase, Terminal

transferase etc., Linkers and Adapters. **8 hours**

2. Gene cloning: cloning vector, Salient features and uses of most commonly used vector i.e.; Plasmid, Bacteriophage, Phagemid, Cosmid, BAC,YAC, PAC and cloning stratigies, Shuttle vector, Expresson vectors, Chromosome walking, Probe preparation and labeling, radio labeling and non radio labeling. Gene libray: Genomic library and cDNA library, Identification of desired cloned gene by Colony hybridization, plaque hybridization and Immunological assay. **12 hours**

3. DNA estimation, Electrophoresis- Agarose electrophoresis, Sodium dodecyl sulphate gel electrophoresis (SDS-PAGE). Polymerase Chain Reaction (PCR), DNA sequencing. Blotting technique: Southern, Northern and Western blotting. **10 hours**

4. Gene transfer: Agrobacterium mediated gene transfer; Ti plasmid, Ri plasmid and T DNA, Cointegrate vector and binary vector, Transformationtechnique, Marker gene, Reporter gene, Virus mediated gene transfer, Direct gene transfer: Electroporation, Particle Bombardment, Microinjection, Macroinjection, Chemical method. **6 hours**

ABT 206: Molecular Tools and Techniques (0+2) credits

Practical: 2 Credits/ 36 hours

1. Handling of laboratory instruments. **4 hours**
2. Isolation of plant genomic DNA. **2 hours**
3. Isolation of bacterial genomic DNA. **2 hours**
4. Isolation of fungal genomic DNA. **2 hours**
5. Isolation of plasmid DNA– mini preparation. **4 hours**
6. Estimation of DNA using Spectrophotometer. **2 hours**
7. Agarose gel electrophoresis. **2 hours**
8. Sodium Dodecyl Sulphate gel electrophoresis (SDS-PAGE). **4 hours**
9. Purification of DNA from Agarose gel. **2 hours**
10. Restriction digestion of DNA and DNA ligation. **4 hours**

ABT 208: Spiritual and Cultural Heritage of India-II (2+0) credits

Theory: 2 Credits/ 36 hours

1. Selected vedic hymns: Medha Suktam, Durga Suktam, Acharyopadesha etc. **2 hour**

2. Swami Vivekananda's message on women's empowerment: the ideal of woman as mother, womanhood personified in Sita, as warrior, eligibility for the highest knowledge, common humanity grounds, respecting the women, all round education of women, develop their own solutions. **12 hours**

3. Swami Vivekananda's message on the uplift of the masses: Dedicate yourself, develop faith in equality and oneness of man, educate the masses, solution to the caste problem. **10 hours**

4. Swami Vivekananda's message on restoring our national glory: India's ideal is spirituality, India's mission is spiritual regeneration of the world, India's solution to life's challenges, India must share the spiritual knowledge with the West and gain material knowledge from them, India is readying for its time under the sun. **12 hours**

GPB 205: Seminar-I (0+1) credit

Semester-III [Total: 14 (T) + 8 (P) = 22 credits/ 396 hours]

ABT 105: Molecular Biology (2+0) credits

Theory: 2 Credits/ 36 hours

1. Historical development of Molecular Biology. Nucleic acid as genetic material with experimental evidences. **4 hours**

2. Nucleic acids: DNA structure; Watson and Crick model, A, B, Z and Triplex DNA; DNA contents and C-Value paradox, denaturation, renaturation and cot curve. Physical and Chemical properties of DNA. RNA: Structure, types and function. **6 hours**

3. DNA replication in prokaryotes and eukaryotes; Enzymes and accessory proteins and their structure and function; fidelity, proof reading, processivity; replication of single stranded circular DNA, DNA repair: Enzymes, photo reactivation, nucleotide excision repair, mismatch correction, SOS response. **8 hours**

4. Transcription: Prokaryotic transcription, transcription unit, promoters- constitutive and inducible, operators; eukaryotic transcription- RNA polymerases structure, types and function; general transcription factors, Post transcriptional modification; RNA processing (processing of mRNA, tRNA and rRNA), RNA splicing. **6 hours**

5. Translation: Structure and function of ribosome; genetic code, properties of genetic code, Wobble hypothesis, Translational frame shifting and RNA editing; protein synthesis in prokaryotes and eukaryotes (initiation, elongation and termination). Post translational modification and transport of proteins. **6 hours**

6. Regulation of gene expression in prokaryotes and eukaryotes. **6 hours**

GPB 301: Breeding of Field Crops-II (2+0) credits

Theory: 2 Credits/ 36 hours

1.CEREALS

Wheat: evolution and distribution of species and forms, wild relatives and germplasm, cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc. Breeding approaches: conventional and non conventional including MAS, emerging challenges at national and international level.

Barley: evolution and distribution of species and forms, wild relatives and germplasm, cytogenetics breeding objectives: yield, quality characters, biotic and abiotic stress resistance. Breeding approaches: conventional and non conventional including MAS, Breeding for malt barley; emerging challenges at national and international level. **8 hours**

2.PULSES

Chickpea: Evolution and distribution of species and forms, wild relatives and germplasm, cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc. Protein quality improvement- conventional and modern plant breeding approaches conventional and non conventional including MAS, progress made. Breeding for anti nutritional factors; emerging challenges at national and international level.

Lentil: evolution, cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc. Breeding approaches-conventional and non conventional including MAS, interspecific crosses- problems, prospects and implications, emerging challenges at national and international level.

Fieldpea: evolution, cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, interspecific crosses problems, prospects and implications, emerging challenges at national and international level. **12 hours**

3.OILSEEDS

Rapeseed and Mustard: evolution and distribution of species and forms wild relatives and germplasm, genetics - cytogenetics and genome relationship; breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. Breeding approaches conventional and non conventional including MAS, emerging challenges at national and international level.Utilisation of wild relatives for yield and quality improvement.

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements **8 hours**

4. Sugarcane: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship. Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc. Forage grasses: Evolution and distribution of species and forms - Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., synthetics, composites and apomixes. **2 hours**

5. Distinguishing features of popular released varieties in- Wheat, barley, lentil, chickpea, fieldpea, mustard and toria, sunflower, sesame, sugarcane and their application to DUS testing. Maintenance of seed purity- Nucleus and Breeder Seed Production; Maintenance Breeding and All India Co-ordinated system of testing and release of crop varieties and hybrids. **6 hours**

ABT 303: Molecular Breeding (2+1) credits

Theory: 2 Credits/ 36 hours

1. DNA marker: Definition, importance, types: RAPD, ISSR, SSR, RFLP, AFLP etc, advantages and limitation, identification of linked marker. **10 hours**

2. Marker Assisted Selection (MAS): Concept, procedure, advantages, Practical achievements, merits and demerits. **8 hours**

3. Breeding of Transgenic crop: Concepts, main features; transgenic breeding vs conventional breeding, procedure, merits and demerits. **8 hours**

4. Quantitative trait loci: Concepts, importance; concepts of RILS and NILS, Procedure of QTL development, practical achievement. **10 hours**

Practical: 1 Credit/ 18 hours

1. Study of RAPD marker, ISSR marker, SSR marker. **8 hours**

2. Phylogenetic relationship study based on molecular marker. **4 hours**

3. Linkage and associationship analysis. **6 hours**

GPB 302: Plant Genetic Resources and Pre-breeding (2+0) credits

Theory: 2 Credits/ 36 hours

1. Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity. **4 hours**

2. Basic genetic resources and transgenes. Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification. **4 hours**

3. Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation. Germplasm conservation- *in situ*, *ex situ*, and on-farm; short, medium and long term conservation strategies for

conservation of orthodox seed and vegetatively propagated crops. **4 hours**

4. Registration of plant genetic resources. PGR data base management; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system. **8 hours**

5. Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets. **4 hours**

6. Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement. **6 hours**

7. Utilization of genetic resources, concept of core and mini-core collections, genetic enhancement/ Pre-breeding for crop improvement including hybrid development. **6 hours**

GPB 303: Breeding for Stress Resistance (2+0) credits

Theory: 2 Credits/ 36 hours

1. Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses - major pests and diseases of economically important crops - Concepts in insect and pathogen resistance. **4 hours**

2. Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defense mechanisms against viruses and bacteria. **6 hours**

2. Types and genetic mechanisms of resistance to biotic stresses -Horizontal and vertical resistance in crop plants. Quantitative resistance/Adult plant resistance and Slow rusting resistance - Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies. **4 hours**

3. Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data. Marker aided selection. Introgression of genes from the wild relatives of crop plants, concept of pyramiding of resistance genes and implication in plant breeding, elimination of linkage drag. Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops Transgenics in the management of biotic stresses. Use of Bt toxins, inhibitors, lectins, chitnases and glucanases for insect pest management- Achievements. **8 hours**

4. Importance and crop specificity of stresses due to temperature, drought, salinity, alkalinity, Aluminium toxicity, and water logging. Genetic and physiological mechanisms governing abiotic stress resistance. Breeding procedures for abiotic stresses including toxicity, deficiency and pollutants/contaminants in soil, water , environment and resistance in selected and important crop plants. Achievements in breeding crop plants for abiotic stress resistance. Utilization of MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc. **14 hours**

Practical : 1 credit / 18 hours

1. Phenotypic screening techniques for important sucking pests and chewing pests in rice and other crops. Traits to be observed at plant and insect level. Phenotypic screening techniques for nematodes and borers; Ways of combating them. **8 hours**

2. Phenotypic screening methods for diseases caused by fungi and bacteria; Symptoms and data recording. **2 hours**

3. Use of standard MAS procedures – for screening resistant types **2 hours**

4. Quality parameters evaluation - Screening crops for drought, alkalinity and flood resistance;

factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies; **4 hours**

5. Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them. **2 hours**

GPB 304: Mutagenesis and mutation breeding (2+1) credits

Theory: 2 Credits/ 36 hours

1. Mutation and its history- Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations- Detection of mutations in lower and higher organisms- paramutations. **2 hours**

2. Mutagenic agents: physical. Radiation types and sources: Ionising and non-ionizing radiations *viz*., X rays, gamma rays, and particles, protons, neutrons and UV rays- Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects -RBE and LET relationships. **6 hours**

3. Effect of mutations on DNA. Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects. Dosimetry- Objects and methods of treatment- Factors influencing mutation: dose rate, acute *vs* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume. **4 hours**

4. Chemical mutagens- Classification - Base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action- Dose determination and factors influencing chemical mutagenesis- Treatment methods using physical and chemical mutagens - Combination treatments; Other causes of mutation- direct and indirect action, comparative evaluation of physical and chemical mutagens. **8 hours**

5. Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras *etc*., Observing mutagen effects in M_2 generation- Estimation of mutagenic efficiency and effectiveness- spectrum of chlorophyll and viable mutations. Mutations in traits with continuous variation**.** **2 hours**

6. Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc*. Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation- Comparative evaluation of physical and chemical mutagens for creation of variability in the same species - Case studies. **4 hours**

7. Use of mutagens in creating oligogenic and polygenic variations- Case studies. *In vitro* mutagenesis- callus and pollen irradiation; Handling of segregating genrations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement,etc) in different crops- Procedures for micro-mutations breeding/polygenic mutations- Achievements of mutation breeding- varieties released across the world- Problems associated with mutation breeding. **8 hours**

8. Use of mutagens in genomics, allele mining, TILLING. **2 hours**

Practical: 1 Credit/ 18 hours

1. Learning the precautions on handling of mutagens; Dosimetry- Studies of different mutagenic agents: Physical mutagens- Studies of different mutagenic agents: Chemical mutagens Treating the plant propagules at different doses of physical and chemical mutagens- Learning combined mutagenic treatments. **4 hours**

2. Calculation of LD50 from previous data, raising the crop for observation- Mutagenic effectiveness and efficiency; Calculating the same from earlier literature- Study of M1 generation- Parameters to be observed; Study of M_2 generation- Parameters to be observed. **6 hours**

3. Mutation breeding in cereals and pulses- Achievements made and an analysis- Mutation breeding in oilseeds and cotton- Achievements and opportunities. **4 hours**

4. combined mutagenic treatments in M1 and subsequent generations in different crops– cereal, pulses, oilseeds, vegetatively propagated crops. **4 hours**

ABT 106: Plant Tissue Culture (2+2) credits

Theory: 2 Credits/ 36 hours

1. History of plant cell and tissue culture, Application of tissue culture in crop improvement, Culture media, Sterilization technique, Totipotency, types of culture, Micro propagation. **10 hours**
2. Organogenesis (direct and indirect), Embryogenesis (direct and indirect), Somaclonal and gametoclonal variation, somatic embryos and artificial seeds- Cryopreservation. **8 hours**
3. Meristem culture vis-à-vis virus elimination, Protoplast culture vis-à-vis wide hybridization, protoplast fusion, somatic hybrids, protoplast viability test, Embryo culture and embryo rescue, Anther culture vis-à-vis dihaploids, Cell suspension culture and secondary metabolites, hardening techniques. **18 hours**

Practical: 2 Credits/ 36 hours

1. Laboratory set up **2 hours**
2. Sterilization of glass goods, plastic wares, media and plant materials **2 hours**
3. Formulation and preparation of media for shoot and root initiation. **4 hours**
4. Fresh Culture for micropropagation **4 hours**
5. Sub culturing **4 hours**
6. Direct organogenesis using suitable explants. **6 hours**
7. Indirect organogenesis using suitable explants **6 hours**
8. Suspension culture development from calli **4 hours**
9. Somatic embryogenesis from calli. **2 hours**
10. Embryo culture, Anther culture **2 hours**
11. Preparation of competent cell. **2 hours**
12. Cloning of DNA. **6 hours**

GPB 305: Seminar –II: Proposed Plan of Dissertation Work (0+1) credits

Semester-IV [Total: 3 (T) + 27 (P) = 30 credits/ 540 hours]

ABT 201: Fundamentals of Crop Protection (3+2) credits

Theory: 3 Credits/ 54 hours

1. Basics of Agricultural Entomology, Acarology, and Nematology: Concepts of pests, type of pests and related group of pesticides. Basic knowledge of insect, life cycle, and metamorphosis, major insect orders and their characteristics. Important insect pests of some important field crops and horticultural crops. Mite: Characteristics, causes of mite pest outbreak, some important species of mite and their damage symptom, predatory mite. Economic importance of nematodes, their damage symptoms and control. IPM with special reference to Chemical control, biological control, Botanical pesticides. Non-insecticidal-chemicals for pest control: Antifeedent, repellant, attractant, hormonal, semio-chemicals, Insect resistance. **20 hours**

2. Basics of Plant Pathology. Fungus: Characteristics of important phyla: Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota, Oomycota, Hypochytriomycota, Plasmodiophoromycota; mode of action. Important fungal diseases of some important field crops and horticultural crops. Phytopathogenic bacteria: Importance, mode of action, important bacterial diseases of some important field crops and horticultural crops. Virus: Symptomatology of important plant viral diseases, transmission, host virus interaction, virus vector relationship, Plant viral diseases of some important field crops and horticultural crops. Disease management with special reference to chemical control, Biological control, antagonistic fungi and bacteria, Disease resistance. **20 hours**

3. Basics of weed science and their control: Weed biology and ecology, weed classification, crop-weed competition, allelopathy, weed indices. Principles of weed management (preventive, control and eradication). Herbicides: classification based on chemical nature, method and time of application; selectivity; mode and mechanism of action of herbicides. factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures. Weed control through bio-herbicides, mycoherbicides and allelochemicals, herbicide resistance in weeds and crops; herbicide rotation. Weed management in major crops and cropping systems. Parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control Integrated weed management. **14 hours**

Practical: 2 Credits/ 36 hours

1. Dose calculation and application of chemical pesticides. **2 hours**
2. Identification of different types of damage/ symptoms by insect pest/ diseases. **4 hours**
3. Collection of insect pest, natural enemy, damaged plant parts and preservation. **4 hours**
4. Collection and dry preservation of diseased specimens of important crops. **4 hours**
5. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters. **2 hours**
6. Identification of different plants with properties of insecticidal action, Production procedure of botanical pesticides. Testingon target group, and isolation of Azadirechtin. **2 hours**
7. Isolation, mother culture development, production, formulation and testing efficiency in laboratory of antagonistic fungi and Bacteria. **4 hours**
8. Isolation, mother culture development, production, formulation and testing efficiency in laboratory of entomo-pathogenic fungi and Bacteria. **6 hours**
9. Multiplication of parasitoids, Predators and coccinellids etc. **4 hours**
10. Identification of important weeds of agricultural crops and preparation of weed herbarium. **2 hours**

GPB 401: Seminar-III (0+1) credits

GPB 402: Dissertation work (0+24) credits

Optional/ Special Papers

GPB 501: Introduction To Bioinformatics (3+1) credits

Theory: 3 Credits/ 54 hours

Unit-I
History and development of concept of bioinformatics; overview of protein and DNA sequences; sequences databases, retrieval and analysis; methods of sequence alignment - local, global pair wise and multiple alignment; Collection and storage of sequences in the laboratory: DNA sequencing; genomic sequencing; cDNA libraries and sequencing cDNA; processing and submission of sequences; computer storage; sequence formats- Gen Bank, EMBL, NCBI, Stanford University, etc.

Unit-II
Introduction to database management and DBMS. Introduction to Perl and Bioperl.

Unit-III
Phylogenetic prediction: Phylogeny and sequence variations; concept of evolutionary trees; methods in phylogeny-maximum parsimony, distance methods, maximum likelihood, reliability of prediction.

Unit-IV
Gene prediction: Gene structure and characteristics; ORF; methods for microbial and Eukaryotic gene predictions. Internet Resources.

Unit-V
Genome analysis: Genome structure and organization-Prokaryotes and Eukaryotes; sequence assembly and gene identification; methods - comparative genomics, proteomics; synteny, functional genomics.

Practical: 1 Credit/ 18 hours

Sequence searching and alignment, writing programs in Perl for bioinformatics

GPB 602 : Diversity Analysis (2+1) credits

Theory: 2 Credits/ 36 hours

UNIT-I
The meaning of diversity, history, importance and its use in agriculture. Assessment of diversity: Morphological, biochemical and molecular.

UNIT-II
Statistical techniques for measuring diversity: Measures of quantitative and qualitative variability, diversity indices; and methods for marker data analysis. Statistical techniques for clustering: Hierarchical and non-hierarchical cluster analysis, algorithms for forming clusters/ dendrograms, data transformation and choice of scales, exposure to various clustering softwares.

UNIT-III
Evolution and Diversity: Phylogenetics, concept of evolutionary trees, rooted and unrooted topology, methods for studying phylogeny-maximum, parsimony, distance methods, maximum likelihood, reliability of prediction. Exposure to various softwares (MEGA, Phylip. NTSYS etc.)

UNIT-IV
Collection of germplasm diversity, required sample size and introduction to various germplasm sampling models, Spatial tools for studying plant germplasm diversity.

Practical: 1 Credit/ 18 hours

Estimation of diversity, Practical exercises using statistical software for clustering. Developing phylogenic trees based on various methods, estimating and locating diversity using DIVA GIS, determination of sample size for collecting diversity

GPB 621: Breeding For Crop Quality Traits (2+1) credits

Theory : 2 Credits/ 36 hours

Unit-I
Nutritional improvement - A human perspective, Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors - Wheat quality-nutritional, rheological, baking properties and fractional aspects; - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

Unit-II
Breeding for grain quality parameters in rice and its analysis- aroma, amylose, GT, gel consistency, elongation ratio, cooking quality, post harvest manipulation for quality improvement – vitamin A enriched and aromatic rice – breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.

Unit-III
Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize- – concept and breeding strategies –kernel mutants and their uses in breeding for quality; Speciality corns; Breeding for quality improvement in forage crops; Genetic resource management for sustaining nutritive quality in crops

Unit-IV
Breeding for quality in pulses; groundnut, sesame, sunflower and minor oilseeds – Fatty acid metabolism and its manipulation to increase PUFA in oil, Brassica-breeding for low erucic acid and glucosinolates; Soybean- breeding for amelioration of anti nutritional factors; Genetic manipulation for quality improvement in cotton.

Unit-V
Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; classification and importance - Nutritional genomics and Second generation transgenics

Practicals: 1 Credit/ 18 hours

Grain quality evaluation in rice; correlating ageing and quality improvement in rice - Quality analysis in millets; a comparison - Quality parameters evaluation in wheat; Quality parameters evaluation in pulses - Quality parameters evaluation in oilseeds - Value addition in crop plants; Post harvest processing of major field crops - Quality improvement in crops through tissue culture techniques - Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

ABT 304: Genomics and Proteomics (2+0) credits

Theory: 2 Credits/ 36 hours

1.Structural genomics: Classical ways of genome analysis, large fragment genomic libraries, physical mapping of genomes, genome sequencing– principles and translation to large scale projects; recognition of coding and non-coding sequences and gene annotation; comparative

genomics. **8 hours**

2. Identification and classification using molecular markers- 16S rRNA typing/ sequencing, EST's and SNP's. **2 hours**

3. Functional genomics: DNA chips and microarray technology and their use in transcriptome analysis; mutants and RNA in functional genomics; metabolomics and ionomics for elucidating metabolic pathways etc. **8 hours**

4. Proteomics: Protein structure, function and purification. Protein analysis (includes measurement of concentration, amino acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; microscale solution isoelectric focusing; peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and differential display proteomics, proteinprotein interaction, Yeast two hybrid system. **10 hours**

5. Pharmacogenetics: High throughput screening in genome for drug discovery- identification of gene targets, pharmacogenetics and drug development, Application of genomics and proteomics in agriculture, human health and industry. **8 hours**