RAMAKRISHNA MISSION VIVEKANANDA EDUCATIONAL & RESEARCH INSTITUTE

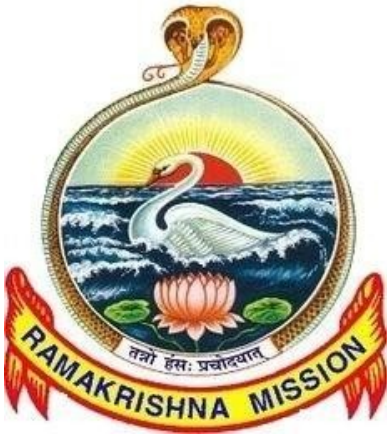
(Declared by Government of India under section 3 of UGC Act, 1956)

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 2021-22)

M. Sc. (Ag.) in 'Genetics and Plant Breeding'
I to IV Semester - 2 Year Course
Syllabus at a Glance

1st Year										1st Semester
Module No.	**Module Name**	**Hrs/week**		**Exam hrs**	**Theory credits**	**Practical credits**	**Total credits**	**Marks**		
		T	**P**					**E**	**I**	**T**
GPB 101	Principles of Genetics	2	1	2	2	1	3	60	40	100
GPB 102	Principles of Cytogenetics	2	1	2	2	1	3	60	40	100
GPB 103	Principles of Plant Breeding	2	1	2	2	1	3	60	40	100
GPB 104	Biostatistics –I	2	1	2	2	1	3	60	40	100
GPB 105*	Principles of Seed Production	3	0	2	3	0	3	30	20	50
GPB 106*	Plant Genetic Resources and their utilization	2	0	2	2	0	2	30	20	50
SCH 101*	Spiritual and Cultural Heritage of India-I	1	0	2	1	0	1	30	20	50
Total Credits= 19/342hrs		T – Theory., P- Practical., E- External., I- Internal., T-Total								

1st Year										2nd Semester
Module No.	**Module Name**	**Hrs/week**		**Exam hrs**	**Theory credits**	**Practical credits**	**Total credits**	**Marks**		
		T	**P**					**E**	**I**	**T**
GPB 201	Breeding of Field Crops-I	2	1	2	2	1	3	60	40	100
GPB 202	Principles of Quantitative Genetics	2	1	2	2	1	3	60	40	100
GPB 203	Analytical Techniques & Instrumental Methods in Soil & Plant Analysis	2	1	2	2	1	3	60	40	100
GPB 204	Heterosis Breeding	2	1	2	2	1	3	60	40	100
GPB 205*	Seminar-I: Presentation on general topics related to Genetics and Plant Breeding	0	1	-	0	1	1	50	00	50
GPB 206*	Biostatistics –II	1	1	2	1	1	2	30	20	50
ABT 206*	Molecular Tools and Techniques	0	2	2	0	2	2	50	00	50
SCH 201*	Spiritual and Cultural Heritage of India-II	1	0	2	1	0	1	30	20	50
CBT 201	Genetic Engineering	3	0	2	3	0	3	60	40	100
Total Credits= 22/396hrs		T – Theory., P- Practical., E- External., I- Internal., T-Total								

2nd Year										3rd Semester
Module No.	Module Name	Hrs/week		Exam hrs	Theory credits	Practical credits	Total credits	Marks		
		T	P					E	I	T
GPB 301*	Breeding of Field Crops-II	2	0	2	2	0	2	30	20	50
GPB 303	Breeding for Stress Resistance	2	1	2	2	1	3	60	40	100
GPB 304	Mutagenesis and mutation breeding	2	1	2	2	1	3	60	40	100
GPB 305*	Seminar –II: Proposed Plan of Project Work	0	1	-	0	1	1	50	00	50
GPB 306	Molecular Breeding	2	1	2	2	1	3	60	40	100
ABT 106	Plant Tissue Culture	2	1	2	2	1	3	60	40	100
CBT 101	Molecular Biology	3	0	2	3	0	3	60	40	100
Total Credits= 18 /324hrs		T – Theory., P- Practical., E- External., I- Internal., T-Total								

2nd Year										4th Semester
Module No.	Module Name	Hrs/week		Exam hrs	Theory credits	Practical credits	Total credits	Marks		
		T	P					E	I	T
GPB 401	Seminar-III: Project Presentation	0	1	-	0	1	1	100	00	100
GPB 402	Project Work	0	24	-	0	24	24	NG		
Total Credits= 25		T – Theory., P- Practical., E- External., I- Internal., T-Total NG-Non-Graded								

Optional/ Special										
Module No.	Module Name	Hrs/week		Exam hrs	Theory credits	Practical credits	Total credits	Marks		
		T	P					E	I	T
GPB 501	Introduction To Bioinformatics	3	1	2	3	1	4	60	40	100
GPB 502	Diversity Analysis	2	1	2	2	1	3	60	40	100
GPB 601	Breeding For Crop Quality Traits	2	1	2	2	1	3	60	40	100
GPB 602*	Genomics and Proteomics	2	0	2	2	0	2	30	20	50
T – Theory., P- Practical., E- External., I- Internal., T-Total										

Note-* highlighted modules in final evaluation counted as doubled (e.g. 50 x 2=100)

Semester-I [Total: 15 (T) + 4 (P) = 19 credits/ 346hours]

GPB 101: Principles of Genetics (2+1)
Credits Theory: 2 Credits/ 36hours

Course Objectives: The objective of the course to learn fundamental concepts of genetics and to develop the analytical skills quantitative and problem-solving skills in classical and molecular genetics. In addition to this, introductory knowledge of gene isolation, gene silencing, DNA sequencing, Genomics and Proteomics will built their conception for advance genetics.

Students Learning Outcomes: On completion of this course, students should be able to:

- Understand the fundamental concepts of gene, Mendelian inheritance and its applications.
- Understand the mechanism of regulation of gene in eukaryotes and prokaryotes, protein biosynthesis and DNA replication.
- Familiarize with the techniques of gene cloning, DNA sequencing, RNA editing, anti-sense RNA etc.
- Develop analytical, quantitative and problem-solving skills in classical and molecular genetics**.**

Syllabus:

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. **4hours**

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. **6hours**

3. Population Genetics: Mendelian population – Random mating population. Frequencies of genes and genotypes- Causes of change. Hardy-Weinberg equilibrium. **2hours**

4. Structural and numerical changes in chromosomes. Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

6hours

5. Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

4hours

6. Regulation of gene activity in prokaryotes and eukaryotes. Molecular chaperones and gene expression. RNA editing. **4hours**

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). **4hours**

8. Genomics and proteomics; Functional andpharmacogenomics;Metagenomics. **2hours**

9. Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. **2hours**

10. Concep

ts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics. **2**

hours Practical: 1 Credit/ 18hours

1. Laboratory exercises in probability and chi-square. **2hours**

2. Demonstration of genetic principles using laboratory organisms. **4hours**

3. Chromosome mapping using three point test cross; Tetrad analysis. **4hours**

4. DNA extraction and PCR amplification. **4hours**

5. Extraction of proteins and isozymes. Use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations. **2hours**

6. Detectio

n of transgenes in the exposed plant material; Visit to transgenic glasshouse and learning the practical considerations. **2hours**

Recommended Textbooks:

- Gardner, E.J. and Snustad, D.P. 1991. Principles of Genetics. John Wiley & Sons. Klug, W.S. and Cummings, M.R. 2003.
- Concepts of Genetics. Peterson Education. Lewin, B. 2008. Genes IX. Jones & Bartlett Publ.Russell, P.J. 1998.
- Genetics. The Benjamin/Cummings Publ. Co.
- Strickberger, M.W. 2008. Genetics. Pearson Education.
- Tamarin, R.H. 1999. Principles of Genetics. Wm. C. Brown Publs.
- Snustad, D.P. and Simmons, M.J. 2006. Genetics, 4th Ed. John Wiley & Sons
- Singh, B.D., Fundamentals of genetics 2014, Kalyani Publishers, New Delhi.

GPB 102: Principles of Cytogenetics (2+1)

Credits Theory: 2 Credits/ 36 hours

Course Objectives: The aim of this course to provide insight into chromosomes structure and function, karyotyping, mapping, variations in chromosomal ploidy and structure and its role in crop evolution. To know the barrier in fertilization

pre and post fertilization and production of haploids and dihaploids and their applications.

Students Learning Outcomes: On completion of this course, students should be able to:

- Understand the structure and its different parts of chromosome, identification of various stages of mitosis and meiosis.
- Gain the knowledge and investigate constitutional and acquired chromosome abnormalities and allow exact identification of break point in chromosome

rearrangements.

- Develop an understanding basic concept of fertilization barrier and it's overcome.
- Demonstrate and prepare the specimen slides of various crops belonging to cereals, pulses, oilseeds, forage crops and their pollen grain measurement.
- Gain hands on experiment of GISH and FISH

Syllabus:

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. **4hours**

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.
   8hours

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.
   8hours

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.
   6hours

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.
   6hours

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.

4hours

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.

   2hours

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

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

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 *invitro.* **2hours**

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. **2hours**

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

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 *insitu* hybridization(GISH). **2hours**

Recommended Textbooks:

- Becker, Kleinsmith and Hardin. 2004. The World of Cell. 5th edition. Pearson Education.
- Carroll, M. 1989. Organelles. The Guilford Press, New York.
- Charles, Burnham. 1993. Discussions in Cytogenetics. Prentice Hall Publications, London
- Darlington, C.D. and L.F. La Cour. 1969. The handling of chromosomes. Georger Allen andUnwin Ltd.
- Elgin, S.C.R. 1995. Chromatin Structure and Gene Expression. IRL Press, Oxford. 224p
- Gupta, P.K. and Tsuchiya, T. 1991. Chromosome Engineering in Plants. Part A. Elsevier.
- Gupta, P.K. 2000. Cytogenetics. Rastogi Publications
- Johannson, D.A. 1975. Plant Microtechnique. McGraw Hill Co, New York.
- Karp, G. 1996. Cell and Molecular Biology: Concepts and Experiments. John-Wiley & Sons, Inc., 773p.
- Khush, G.S. and Rick R. 1981. Cytogenetics of Aneuploids, Academic Press.
- Sharma, A.K. and Sharma, A. 1988. Chromosome techniques: Theory and practice, Butterworth,London.
- Sumner, A.T. 1982. Chromosome banding. Unwin Hyman Publishers, London.

GPB 103: Principles of Plant Breeding

(2+1)Credits Theory: 2 Credits/ 36hours

Course Objectives: This course has been designed to provide a basic introduction to concepts of plant breeding. This course also addresses insight

into the modes of reproduction and genetic consequences, breeding methods for crop improvement.

Students Learning Outcomes: On completion of this course, students should be able to:

- Acquaint with the basic concept of plant breeding and its objectives.
- Identify the characteristics of self and cross pollinated plants.
- Determine breeding methodology appropriate for plants with different mating systems
- Learn basic statistical analysis and various experimental designs related to plant breeding.
- Well acquaint with the floral biology, selfing and crossing techniques of self and cross pollinated crops.

Syllabus:

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 - Centers of Origin- biodiversity and its significance. **2hours**

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. **6hours**

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

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). **8hours**

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. **8hours**

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

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. **2hours**

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

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 andcrossingtechniques. **6hours**

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

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

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

Recommended Textbooks:

- Allard, R. W.1981. Principles of Plant Breeding. John Wiley & Sons, London.
- Chopra, V.L. 2001. Breeding Field Crops. Oxford & IBH, New Delhi.
- Chopra, V.L. 2004. Plant Breeding. Oxford & IBH, New Delhi.
- Singh, B.D.2006. Plant Breeding. Kalyani Publishers, New Delhi.
- Singh, P. 2002. Objective Genetics and Plant Breeding. Kalyani Publishers, New Delhi.
- Singh, P. 2006. Essentials of Plant Breeding, Kalyani Publishers, New Delhi.

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

Theory: 2 Credits/ 36 hours

Course Objectives: The aim of this course to make students understand elementary statistics, meaning and its importance. Development analytical abilities to present descriptional data into statistical form. Further, acquainted with various statistical software which is used to carry out statistical analysis.

Students Learning Outcomes: On completion of this course, students should be able to:

- Recognize the principal concepts about agricultural statistics.
- Identify distribution form relating to the variable or variables
- Demonstrate the familiarity with intermediate statistical theory and methods, statistical inference, linear regression, categorical data analysis.
- Arrange the results of the hypotheses testing and make statistical decision.

Syllabus:

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). **6hours**

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. **4hours**

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

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. **6hours**

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

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

Practical: 1 Credit/ 18 hours

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

Tabular presentation. **2hours**
2. Practical on mean, median and mode. **4hours**
3. Analysis of measures of dispersion and skewness and kurtosis. **4hours**
4. Analysis of correlationandregression. **4hours**
5. Study on Z-test, t-test, F-test,χ2test. **2hours**
6. Use of Computer in Research (Concepts only)- entry; Data Presentation and Analysis using appropriate Software: Statistical Packages.
2hours

Recommended Textbooks:

- Goulden, C.H. (1952). Methods of Statistical Analysis, 2/e, John Wiley, New York.
- Hoshmand A. Reza 1988. Statistical Methods for Agricultural Sciences. Timber Press, Portland, Oregan, USA.
- Kempthorne, O. (1957). An Introduction to Genetic Statistics, John Willey, New York.
- Kempton RA and Fox PN (1997). Statistical Methods for Plant Variety Evaluation. Chapman and Hall
- Panse, V.C. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.
- Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods, 7/e. Iowa State Univ. Press, Ames, Iowa.
- Steel, R.G.D. and Torrie , H.H. (1960). Principles and Procedures of Statistics. McGraw- Hill, New York.
- Gomez, AG and Gomez, AA (1994). Statistical Procedures for Agricultural Research, 2/e. John Wiley & Sons, New York.

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

Credits Theory: 3 Credits/ 54hours

Course Objectives: This course is designed to provide deep insight knowledge of seed and their role in agriculture. It also provides principles followed during seed production, conditioning, testing, seed laws regulation and organization relating to seed distribution and use.

Students Learning Outcomes: On completion of this course, students should be able to:

- Enhance the knowledge of seed biology, seed quality, seed production, seed storage and seed certification.
- Develop an understanding of seed development, germination, vigor, deterioration and the relationship between laboratory tests and field performance.
- Acquaint with the principles of seed production for agronomic and horticultural crops within and outside of the region of adaptation and the techniques used in seed conditioning.

- Understand seed increase systems, seed testing and the laws and regulations related to marketing high quality seed.

Syllabus:

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. **4hours**

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

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.
4hours

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

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

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

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 andstorage.
16hours

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.
4hours

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.
6hours

Recommended Textbooks:

- Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
- Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding. CCS HAU Hisar.
- Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.
- McDonald MB Jr& Copeland LO. 1997. Seed Production: Principles andPractices. Chapman & Hall.
- Musil AF. 1967. Identification of Crop and Weed Seeds. Handbook No.219, USDA, Washington, DC.
- Poehlman JM &Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH.
- Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani.
- Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.

- Tunwar NS & Singh SV. 1985. Handbook of Cultivars. ICAR.

GPB 106: Plant Genetic Resources and their utilization (2+0) credits Theory: 2 Credits/ 36hours

Course Objectives: This course is designed to understand the importance of plant genetic resources and their conservation. This course is dealing with the principles, collection, characterization, evaluation and cataloging the plant genetic resources. Further, the

objectives are to enhance the use of standard protocols for routine gene bank operations, awareness of international and national policy instruments and regimes concerning access to an exchange of genetic resources. Students will be able to understand morphological and molecular techniques to characterize and evaluation plant genetic resources.

Students Learning Outcomes: On completion of this course, students should be able to

- Understand the importance, need, conservation and utilization of plant genetic resources.
- Acquaint with procedure of registration of plant genetic resources and their data base management.
- Familiarize with term geographical indicators, intellectual property rights and trade secrets.

Syllabus:

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. **4hours**

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

3. Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation. Germplasm conservation-*insitu,exsitu* and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops. **4hours**

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, *suigeneris* system. **8hours**

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

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. **6hours**

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

Recommended Textbooks:

- Paroda RS & Arora RK. 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.
- Singh BP. 1993. Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management. Indo-US PGR Project Management.
- Stace CA. Plant Taxonomy and Biosystematics 2nd Ed. Cambridge Univ. Press.
- Di Castri F &Younes T. 1996. Biodiversity Science and Development: Towards New Partnership. CABI & International Union for Biol. Sci. France.
- Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.

- Briggs D. 1997. Plant Variation and Evolution. Science Publ.
- Valuation and Conservation of Biodiversity; Interdisciplinary Perspectives on the Convention on Biological Diversity by Michael Markussen et al. Springer 2005.
- Use of Biodiversity: Access to Genetic Resources and Benefit Sharing by Kerry Ten Kate and Sarah A Lai4rd; Earthscan 2002.
- Providing Protection For Plant Genetic Resources: Patents, Sui Generis Systems And Biopartnerships; Publisher: Kluwer Academic Press, ISBN : 9041188754; Distributer : Landmark Ltd.

SCH 101: Spiritual and Cultural Heritage of India – I (1+0 credits)

Theory: 1 Credits/ 18 hours

Course Objectives: This course is designed to familiarize the students with Swami Vivekananda's comprehensive philosophy of education and its scope in its individual and social dimensions. The student will be exposed to the high ideals of education through selected teachings of Swami Vivekananda and guided to understand and approach their role as a citizen with the right attitude. The student would be given a clear picture of the challenges faced by the society and the effective method for addressing them. The course would cover in detail the idea of education in all its aspects– the effective method for acquiring knowledge, the way to apply education to solve the problems of an individual, and the role of education in addressing the short-term and long-term needs of the society.

Students Learning Outcomes: On completion of this course, students should be able to:

- Embrace their role as a student and an individual-in the-making holding immense promise to the society
- Understand the problems faced by the society/nation and the effective approach for solving them
- Develop a comprehensive idea of education in all its aspects in light of Swami Vivekananda's teachings
- Understand how to apply education to solve the challenges faced in life
- Develop an understanding of the effective method of acquiring and transferring knowledge.

Syllabus:

- Shanti Mantras and some selected *Vedic* hymns. **2 hours**
- Life of Swami Vivekanada (Journey from Narendranath Datta to Swami Vivekananda) and his speech at Parliament of Religion. **4 hours**

- Swami Vivekananda on India: India's eminence, Life centre, Mission and Future. **2 hours**
- India's decadence:
- (a) Its Causes - We are to blame, Ignoring the past, Narrowing our outlook, Perversion of religion, Tyaranny over massesn Neglect of women. **2 hours**
- (b) It's symptoms and Cure – Cultural heresey and fanaticism, Physical weakness, Lack of faith in ourselves etc. **2 hours**
- Essentials for Regeneration: Training Sincere Workers, Deluging the Land with Spiritual Ideals, Social Reform, Its Method. **3 hours**
- Education the Pancea of all social evils: The present system, True Education, Ideal Method – Concentration and Detachment, Brahmacharya, Shraddha, Character, Communion with Nature, Gurukula system, Psychological approach, Presenent Need and Swami's Plan. **3 hours**

Recommended Textbooks:

- Swami Tejasananda. (1995). *A Short Life of Swami Vivekananda*. Advaita Ashrama.
- Swami Vivekananda. (2008). *My Idea of Education*. Advaita Ashrama.
- Swami Vivekananda. (1918). *Lectures from Colombo to Almora*. Advaita Ashrama.

Semester-II [Total: 13 (T) + 9 (P) = 22 credits/ 396hours]

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

credits Theory: 2 Credits/ 36 hours

Course Objectives: The objectives of this course is to understand and well acquainted with various important *Kharif* season crops like Rice, Maize, Pearl millet, Pigeon pea, groundnut, soybean, cotton etc. and also to provide insight into recent advances in improvement using conventional and modern biotechnological approaches.

Students Learning Outcomes: On completion of this course, students should be able to:

- Understand crop at morphological, physiological, biochemical and molecular level.
- Accustom with important breeding objectives, major thrust area of research of specific crop, breeding methods- conventional and modern methods and their implications.
- Get inspire from the learning significant achievements from the major crops like Rice, Pigeon pea, Cotton etc.
- Demonstrate emasculation, pollination techniques of various *Kharif* crops and evaluate the germplasm on the basis of various yield, yield attributing parameters , quality traits, biotic and abiotic stress related parameters to develop climate resilient varieties.

Syllabus:

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.

16hours

2. PULSES

Pigeon pea: Evolution and distribution of species and forms; Wildrelatives 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. **8hours**

3. OILSEEDS

Groundnut: Evolution and distribution of species and forms; Wildrelatives 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. **6hours**

4. FIBRECROPS

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. **2hours**

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. **4hours**

Practical: 1 Credit/ 18 hours

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

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 **6hours**

3. Evaluating the germplasm of rice, moong bean, maize for yield, quality and resistance parameter. **6hours**

4. Field and lab visit of the concerned crops **4hours**

Recommended Textbooks:

- Agarwal, R.L. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH Publishing Co.Pvt Ltd.Bahl, P.N. and Salimath,
- P.M. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol 1Pulses and Oilseeds. Oxford & IBH Publsihing Co Pvt Ltd, New Delhi.
- Chandraratna, M.F. 1964. Genetics and Breeding of Rice. Longmans. 389p.

- Chopra, V.L. and ShyamPrakash. 2002. Evolution and adaptation of cereal crops. Oxford and IBH
- Gill, K.S. 1991. Pearl Millet and its Improvement. Indian Council of Agricultural Research, New Delhi.
- IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier Publishing Company. Amsterdam.
- IRRI. 1996. Rice Genetics III. Proceedings of the International Rice Genetics Symposium. IRRI, Philippines.
- IRRI. 2000. Rice Genetics IV. Proceedings of the International Rice Genetics Symposium,

Philippines.
- Jennings, P.R., Coffman, W.R. and Kauffman, H.E. 1979. Rice Improvement. IRRI, Philippines. 186p.
- Murty, D.S., Tabo, R. and Ajayi, O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru
- Nanda, J.S. 1997. Manual on Rice Breeding, Kalyani Publishers, Ludhiana. 120p.
- Ram, H.H. and Singh, H.G. 1993. Crop Breeding and Genetics. Kalyani Publishers, Ludhiana.
- Singh, H.G., Mishra, S.N., Singh, T.B., Ram, H.H. and Singh, D.P. (Eds). 1994. Crop Breeding in India. International Book Distributing Co. Chandigarh.
- Slafer GA. (Ed). 1994. Genetic Improvement of Field Crops. Marcel Dekker Inc. Walden DB. 1978. Maize Breeding and Genetics. John Wiley and Sons, New York.

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

credits Theory: 2 Credits/ 36hours

Course Objectives: The main objective is to impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects. This course provides the basic principles and concepts of quantitative genetics that are important for understanding genetic improvement in breeding population and how to make more effective selection decisions.

Students Learning Outcomes: On completion of this course, students should be able to:

- Develop the understanding genetic principles behind quantitative phenotypic differences and for assessing the genetic and environmental components in variation and simulate and analyze small data sets with MS-Excel, OPSTAT programs..
- Familiarize different methods of design, its execution, analyse, and interpret results of experiments involving polygenically controlled characters of interest in a plant breeding program.

Syllabus:

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.
6hours

2. Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance. **4hours**

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.

6hours

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.
14hours

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. **6hours**

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. **4hours**.

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 geneactions. **8hours**

3. Line x tester analysis and interpretation of results - Estimation of heterosis: standard, mid- parental and better-parental heterosis - Estimation of inbreeding depression.
2hours

4. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interaction , Models in stability analysis.
2hours

5. Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation.
2hours

Recommended Textbooks:

- Bos, I. and Caligari, P. 1995. Selection Methods in Plant Breeding.Chapman & Hall.
- Falconer, D.S. and Mackay, J. 1998.Introduction to Quantitative Genetics.Longman.
- Mather, K. and Jinks, J.L. 1971. Biometrical Genetics.Chapman & Hall.
- Mather, K. and Jinks, J.L. 1983. Introduction to Biometrical Genetics.Chapman & Hall.
- Nadarajan, N. and Gunasekaran, M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding.Kalyani.
- Naryanan, S.S. and Singh, P. 2007. Biometrical Techniques in Plant Breeding.Kalyani.
- Singh, P. and Narayanan, S.S. 1993. Biometrical Techniques in Plant Breeding.Kalyani.
- Singh, R.K. and Choudhary, B.D. 1987. Biometrical Methods in Quantitative Genetics.Kalyani.
- Weir, D.S. 1990.Genetic Data Analysis.Methods for Discrete Population Genetic Data.Sinauer Associates.
- Wricke, G. and Weber, W.E. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

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

Theory: 1 Credit/ 18hours

Course Objectives: The aim of this course studentare able to know the basic of chemistry related to soil and plant to carry out different chemical-physical analysis for understanding the key mechanism of plant. The course is designed to familiar with different instruments, techniques which generally used to determine the content in plant.

Students Learning Outcomes: On completion of this course, students should be able to:

- Gain in proficiency in sampling prior to analysis.
- Understand and capability of performing basic chemical processes in an analytical laboratory.
- Perform with confidently measurements on basic analytical instruments (photometers, spectrometers, chromatographs, ion-selective electrodes, UV-vis spectrophotometer assay, HPTLC fingerprint)

Syllabus:

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.
2hours

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 differentmethods.
4hours

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

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.
4hours

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.
2hours

Practical: 2 Credits/ 36 hours

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

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

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.
6hours

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

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

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

Recommended Textbooks:

- Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers. FDCO, New Delhi.
- Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*.ELBS Longman.

GPB 204: Heterosis Breeding (2+1) credits

Theory: 2 Credits/ 36 hours

Course Objectives: The objectives of this course to understand the theories, mechanism of heterosis and its commercial exploitation for yield through conventional and modern biotechnological approaches.

Students Learning Outcomes: On completion of this course, students should be able to:

- Understand the mechanism of heterosis and its physiological, biochemical and molecular factors underlining heterosis.
- Learn divergence and genetic analyses for the prediction of heterosis.
- Understand the different types of male sterility and self-incompatibility in the development of hybrid seed production.

Syllabus:

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.
2hours

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.
4hours

3. Predict ion 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.
4hours

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. **8hours**

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.
8hours

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

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. **4hours**

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

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. **4hours**

4. Evaluation of restorer, cytoplasmic sterile and partial restorer linesinRice. **4hours**

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

6. Study of some TGMS linesinRice. **2hours**

Recommended Textbooks:

- Akin, E. 1979.The geometry of population genetics.Springer-Verlag, Berlin Ben Hiu Lin. 1998.
- Statistical genomics – linkage, mapping and QTL analysis. CRC Press
- Coors, J.C. and Pandey, S. 1999. Genetics and Exploitation of Heterosis in Crops.American Society of Agronomy, Inc. & Crop Science Society of American, Inc.
- Hartl, D.L. 2000.A primer of population genetics. 3rd ed. Sinauer Assoc. Inc. Publishers
- De Joung, G. 1988. Population Genetics and Evolution. Springer-Verlag, Berlin
- Montgomery, D.C. 2001. Design and analysis of experiments. 5th edition, Wiley and Sons
- Mukherjee, B.K. 1995. The Heterosis Phenomenon.Kalyani Publishers
- Srivastava, S. and Tyagi, R. 1997. Selected problems in Genetics, 2 Volumes, Anmol Publications.
- Rai, M. and Maurya, S. 1995. Hybrid Research and Development;Indian Society of Seed Technology.
- Virmani, S.S. 1994. Heterosis and Hybrid Rice Breeding.Monographs of "Theoretical and Applied Genetics", Springer-Verlag.
- James A. Birchler, et al. 2010. Heterosis.The Plant Cell. Vol.22: 2105-2112.

GPB 206: Biostatistics –II (1+1) credits

Theory: 1 Credit/ 18 hours

Course Objectives: The objectives of this course to give a comprehensive knowledge on how to design a study or experiment so that the results of the experiments are free from errors or biases, and then how to draw a valid conclusion using the results so obtained.

Students Learning Outcomes: On completion of this course, students should be able to

- Acquire knowledge on designing experiments, collection and analysis of agricultural research data.

Syllabus:

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

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

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

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

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

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

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

Practical: 1 Credit/ 18 hours

1. ANOVA of Completely Randomized Design(CRD). **2 hours**
2. ANOVA of Randomized Block Design (RBD). **2hours**
3. ANOVA of Latin SquareDesign(LSD). **2hours**
4. ANOVA of SplitPlotDesign. **4hours**
5. ANOVA of Factorial Design. **4hours**
6. Analysi
s of variance using appropriate Software: Statistical Packages.
4hours Recommended Textbooks:

- Goulden, C.H. (1952). Methods of Statistical Analysis, 2/e, John Wiley, New York.
- Hoshmand A. Reza 1988. Statistical Methods for Agricultural Sciences. Timber Press, Portland, Oregan, USA.
- Kempthorne, O. (1957). An Introduction to Genetic Statistics, John Willey, New York.
- Kempton RA and Fox PN (1997). Statistical Methods for Plant Variety Evaluation.Chapman and Hall
- Panse, V.C. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.

- Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods, 7/e. Iowa State Univ. Press, Ames, Iowa.
- Steel, R.G.D. and Torrie , H.H. (1960). Principles and Procedures of Statistics. McGraw- Hill, New York.
- Gomez, AG and Gomez, AA (1994). Statistical Procedures for Agricultural Research, 2/e. John Wiley & Sons, New York.

CBT 201: Genetic Engineering (3+0) credits

Theory: 3 Credits/ 54 hours

Course Objectives: The objectives of this course are to teach various approaches to genetic

engineering that students can apply in their future career in biological research as well as in biotechnology industry. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course. This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

Student Learning Outcomes: On completion of this course, students should be able to:

- Endow themselves with strong theoretical knowledge of this technology;
- Gain working knowledge of gene silencing and editing tools and methods and appreciate their relevance for investigating specific contemporary biological questions;
- Take up biological research as well as find placement in the relevant biotech industry.

Syllabus:

1. Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric ailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far- western and colony hybridization, fluorescence in situ hybridization. **10hours**

2. Plasmids; Bacteriophages; M13mp vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tagetc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors. **10 hours**

3. Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR: multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencingmethods;enzymaticDNAsequencing;chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; Mutation detection: SSCP, DGGE, RFLP. **10 hours**

4. Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and Total RNA; Reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays: genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions:electrophoretic mobility shift assay; DNase I foot printing; methyl

interference assay, chromatin immune precipitation; protein- protein interactions using yeast two-hybrid system; phagedisplay.

12 hours

5. Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principleandapplicationofgenesilencing;geneknockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic

manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebrafish)andchick;Transgenics:genereplacement;gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR- CAS.

12 hours

Recommended Textbooks:

- Brown, TA. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
- Old, R.W.; Primrose, S.B.; &Twyman, R.M.; (2001). Principles of GeneManipulation: An Introduction to Genetic Engineering. Oxford: BlackwellScientific Publications.
- Green, MR., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

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

Practical: 2 Credits/ 36 hours

Course Objectives: The objectives of this practical based course to hands on the basic principles of molecular biology like DNA extraction from plant, bacteria, fungal etc. Also to well acquainted with PCR machines and its handling.

Student Learning Outcomes: On completion of this course, students should be able to:

- Isolate and purify DNA from plant, bacteria, fungus etc.
- Run the Agarose gel electrophoresis.
- Explain the principles of PCR and knows the general safety routines for laboratory work

Syllabus:

1. Handling of laboratory instruments.	**4hours**
2. Isolation of plantgenomic DNA.	**2hours**
3. Isolation of bacterialgenomicDNA.	**2hours**
4. Isolation of fungalgenomicDNA.	**2hours**
5. Isolation of plasmid DNA–minipreparation.	**4hours**
6. Estimation of DNAusingSpectrophotometer.	**2hours**
7. Agarosegelelectrophoresis.	**2hours**
8. Sodium Dodecyl Sulphate gelelectrophoresis(SDS-PAGE).	**4hours**
9. Purification of DNA fromAgarosegel.	**2hours**
10. Restriction digestion of DNA andDNAligation.	**4hours**

SCH 201: Spiritual and Cultural Heritage of India-II

(1+0)credits Theory: 1 Credits/ 18hours

Course Objectives:

This course is designed to impart to the student a comprehensive understanding of various social challenges faced by modern India and its way forward in light of Swami Vivekananda’s insightful study of these subjects. The course would familiarize the student with Swami Vivekananda’s ideas on women empowerment combining ancient ideals of womanhood with scope for adapting to the needs of the modern society. The importance of improving the

condition of the poorer classes, an essential feature of an enlightened society, will be discussed in detail. The greater role that an enlightened India would play in the modern world and the blueprint for its harmonious and beneficent relationship with the rest of the world will be discussed.

Student Learning Outcomes: On completion of this course, students should be able to:

- Chant selected Vedic hymns that bring the student in touch with the ideas of traditional Indian Knowledge.
- Understand the traditional Indian ideal of womanhood and the way to bring back a respectable position for women in the society compatible with both the ancient ideals and the modern needs.
- Recognize the importance of serving equally the whole society, especially the lower classes, and feel inspired to dedicate their knowledge and skills to this cause.
- Understand the great future role that India has to play in the world and her relationship with other nations involving both teaching and learning, to the mutual benefit of both.

Syllabus:

1. Selected Shlokas from Srimad Bhagavad Gita on shaping own destiny, secret of work and success, concentration of mind: Bhagavad Gita-6.5, Bhagavad Gita-6.6, Bhagavad Gita-2.3, Bhagavad Gita-2.47, Bhagavad Gita-2.48, Bhagavad Gita-6.38, Bhagavad Gita-6.35. **3 hours**

2. 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. **3 hours**

3. Swami Vivekananda’s view on caste problem and its solution: Caste is a social institution not a religious institution, Ideal of Brahmin-ness, Characteristics of noble minded man, Untouchability is form of mental disease, Uplifting all to the state of ideal Brahminhood. **3 hours**

4. 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. **3 hours**

5. 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. **3 hours**

6. Swami Vivekananda's thought on Karma Yoga: Karma in its effect on character is the most tremendous power that man has to deal with, what is duty, power of purity and chastity, How to make the duty sweeter in daily life. **3 hours**

Recommended Textbooks:

- Swami Vivekananda. (1946). Swami Vivekananda on India and Her Problems.Compiled by Swami Nirvedananda.AdvaitaAshrama.
- Swami Vivekananda. (1918). Lectures from Colombo to Almora.AdvaitaAshrama.
- Swami Chidananda. (2013). SankshiptaSasvara Veda Mantrah (Sanskrit). SriRamakrishna Ashrama.

GPB 205: Seminar-I – Presentation on general topics related to Genetics and Plant Breeding (0+1) credit

Course Objectives: The aim of this course to learn the students' presentation skills on general topic on Plant Breeding and Genetics. This course is dealing the evaluation of students on the basis of understanding of topics,their deliverance and presentation skills.

Semester-III [Total: 13 (T) + 5 (P) = 18 credits/ 324hours]

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

Credits Theory: 2 Credits/ 36 hours

Course Objectives: To provide insight into recent advances in improvement of *Rabi* cereals and forage crops, sugarcane legumes and oilseeds crops using conventional and modern biotechnological approaches.

Student Learning Outcomes: On completion of this course, students should be able to:

- Learn to use the descriptors in various crops for selection of superior genotypes.
- Understand crop at morphological, physiological, biochemical and molecular level.
- Accustom with important breeding objectives, major thrust area of research of specific crop, breeding methods- conventional and modern methods and their implications.
- Get inspire from the learning significant achievements from the major *Rabi* crops like Wheat, Barley, Chickpea, Rapeseed, Mustard, Sugarcane etc.

Syllabus:

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 andinternationallevel.

12hours

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. Utilization 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 **8hours**

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. **2hours**

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. **6hours**

Recommended Textbooks:

- Ram, H.H. and Singh, H.G. 1993. Crop Breeding and Genetics. Kalyani publishers, Ludhiana.
- Singh, H.G., Mishra, S.N., Singh, T.B., Ram, H.H. and Singh, D.P. (Eds). 1994. Crop Breeding in India. International Book Distributing Co. Chandigarh

GPB 303: Breeding for Stress Resistance

(2+1)credits Theory: 2 Credits/ 36hours

Course Objectives: The objectives of this course to understand the mechanism of plant in biotic and abiotic stress. It provides in details analysis and inheritance of resistance variation in stress condition, host pathogen relationship, gene for gene hypotheses, systematic acquired resistance etc.

Student Learning Outcomes: On completion of this course, students should be able to:

- Understand the different aspects of stress conditions i.e. mechanism, classification, defense response to pathogen, acquired and innate immunity, gene for gene hypotheses etc.

- Use knowledge in plant pathogen interactions and genetics in breeding program for plant resistance to pest and diseases.
- Judge which plant breeding method are appropriate for introducing resistance to plant varieties.

- Learn different phenotypic screening methods for important pest and diseases and also screen the crops for drought , salinity, submergence abiotic stress etc.

- Use biotechnological advances e.g. MAS in breeding for resistance.

Syllabus:

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. **4hours**

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. **6hours**

3. 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 again studies. **4hours**

4. 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. **8hours**

5. 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. **8hours**

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

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

4. Quality parameters evaluation - Screening crops for drought, alkalinity and floodresistance; factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies **4hours**

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

Recommended Textbooks:

- Fritz, R.S. and Simms, E.L. (Eds). 1992. Plant resistance to herbivores and pathogens: Ecology,evolution and genetics. The University of Chicago Press. Chicago.

- Russel, G.E. 1978. Plant breeding for pest and disease resistance. Butterworths. London.
- Van der Plank, J.E. 1982. Host -pathogen interactions in plant disease. Academic Press, London.
- Blumm, A. 1988. Plant Breeding for Stress Environments. CRC Press Inc., USA.
- Christiansen, M.N. and Lewis, C.F. 1982. Breeding plants for less favourable environments. Wiley International science, New York.
- Turener, N.C. and Kramer, P.J. 1980. Adaptation of plants to water and high temperature stress.Jon Wiley & Sons, New York..

GPB 304: Mutagenesis and mutation breeding

(2+1)credits Theory: 2 Credits/ 36hours

Course Objectives: To provide insight into mutations, mutagens & their mode of action, effects, screening and their utility and application in crop improvement. To impart the knowledge of general principles of radiation and various tests or methods for detection of radiation effects on the living cells, genetic risk involved and perspectives of advances made.

Student Learning Outcomes: On completion of this course, students should be able to:

- Learn about nature and classification of mutations; handling of the various physical and chemical mutagens.
- Understand the effect of mutations on DNA;
- Know about the in-vitromutagenesis; allele mining, TILLING etc.
- Hand on the mutatgen LD50 treatment on germplasm, observation the traits before and after treatment.

Syllabus:

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.
2hours

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.
6hours

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.
4hours

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.

8hours

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**.**

2hours

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. **4hours**

7. Use of mutagens in creating oligogenic and polygenic variations- Case studies. *In vitro* mutagenesis- callus and pollen irradiation; Handling of segregating generations 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. **8hours**

8. Use of mutagens in genomics, allele mining, TILLING.

2hours 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. **4hours**

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. **6hours**

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

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

Recommended Textbooks:

- International Atomic Energey Agency, 1970. Manual on Mutation Breeding. IAEA, Vienna,Alper, T. 1979. Cellular Radiobiology. Cambridge University Press, London.
- Chadwick, K.H. and Leenhouts, H.P. 1981.The Molecular theory of Radiation Biology.SpringerVerlag, New York.
- Strickberger. 1996. Genetics. Prentice Hall Publications
- Mutation detection: a practical approach. 2000. Cotton, R.G.H., E. Edkin and S. Forrest.

GPB 306: Molecular Breeding (2+1) credits

Theory: 2 Credits/ 36

hours Course Objectives:

The main aim of this course to familiar with the different molecular marker, their advantages and limitations. This course provides knowledge about tools and strategies used in breeding program, combining quantitative genetics and biotechnology to identify the genomic regions containing genes of interest.

Student Learning Outcomes: On completion of this course, students should be ble to:

- Well acquainted with different types of molecular markers like RAPD, ISSR, SSR,

RFLP, AFLP etc., their advantages and disadvantages and be able to use them in the development of cultivar.

- Understand the principles behind QTL mapping and be able to know when and how to apply them in cultivar development.
- Learn the concept and development of RIL's and NIL's and their use in QTL mapping.
- Perform construction of linkage mapping, association mapping.

Syllabus:

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

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

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

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

Practical: 1 Credit/ 18 hours

1. Study of RAPD marker, ISSR marker, SSR marker. **8hours**
2. Phylogenetic relationship study based on molecular marker. **4hours**
3. Linkage and association ship analysis. **6hours**

Recommended Textbooks:

- Anolles, G. C. and Gresshoff, P.M., (1997), DNA markers– Protocols,Applications and Overviews. Wiley-Liss, New York.
- Henry R. J., (2005), Plant Genotyping: the DNA Fingerprinting of Plants. CABI,New Delhi.
- R.K. Varshney, R. Tuberosa, (2008). Genomics Assisted Crop Improvement,Springer.

CBT 101: Molecular Biology (3+0) credits

Theory: 3 Credits/ 54

hours Course Objectives:

The objectives of this course are to make students understand how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information in prokaryotes and eukaryotic cells.

Further, to appreciate the subject of molecular biology as a dynamic and ever-changing experimental science.

Student Learning Outcomes: On completion of this course, students should be able to:

- Gain fundamental knowledge on molecular architecture of prokaryotic and eukaryotic genomes;
- Understand the various molecular events that lead to duplication of DNA, recombination of genes, transcription and translation following a central dogma;
- Understand molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes.

Syllabus:

1. **Structure of DNA:** A,B,Z and triplex DNA; Central dogma, DNA and RNA as genetic material; DNA contents and C- value paradox; melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA. RNA: Structure, and Function.
   10hours

2. **Replication:** Initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory Proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle; DNA Damaging agents: Physical, chemical and Biological mutagens; Types of damage caused by endogenous and exogenous agents; Mutations: nonsense, missense, silent and point mutations, frame shift mutations; Intragenic and Intergenic suppression. DNA repair mechanisms: direct reversal, photo reactivation, base excision repair, nucleotide excision repair, mismatch repair, double strand break repair, SOS repair; Recombination: Chi sequences in prokaryotes; Homologous, non-homologous and site specific recombination. **12hours**

3. **RNA Transcription, RNA Processing and Regulation in Prokaryotes:** Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription: RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: lac, trp, his operons, attenuation, anti-termination, stringent control, translational control, DNA re- arrangement, two component system; regulatory RNA: ribo switch, tmRNA, antisense RNA; transcriptional control in lambda phage. **12hours**

4. **RNA Transcription, RNA Processing and Regulationin Eukaryotes:** Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription: RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5’-Cap formation; 3’-end processing of RNAs and polyadenylation; loop model of translation; Splicing of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing,polyadenylation;mRNAstabilityanddegradation: degradation and

surveillance pathways; RNA editing; Nuclear export of mRNA; Catalytic RNA: Group I and Group II introns splicing, Peptidyl transferase; Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; Silencers and insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix,, omeo domain;C2H2z in cfinger, multi cysteine zincfinger, basic DNA binding domains (leucine zipper, helix-loop- helix), nuclear receptors; Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors;Nuclear receptor; histone modifications and chromatin remodeling.

12hours

5. **Protein Translation, Posttranslational Modifications and Control in Prokaryotes and Eukaryotes:** Ribosomes; Composition and assembly universal genetic code; Genetic code in mitochondria Degeneracy; of codons; Termination codons; Wobble hypothesis; Iso accepting tRNA; Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins; Translational control;Protein stability; Protein turnover and degradation. **8hours**

Recommended Textbooks:

- Bruce A.2004. Essential Cell Biology. Garland.
- Karp G.2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.
- Klug WS & Cummings MR 2003.Concepts of Genetics. Scot, Foreman & Co.
- Lewin B. 2008. IX Genes. John Wiley & Sons
- Lodish H, Berk A &Zipursky SL. 2004.Molecular Cell Biology.5TH Ed. WHFreeman.
- Nelson DL & Cox MM. 2005.Lehninger's Principles of Biochemistry. WH Freeman& Co.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley Publ. Co.
- Lewin B. 2008. Genes IX. John Wiley & Sons.
- Schleif R.1986. Genetics and Molecular Biology.Addison-Wesley.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Brown TA. 2002. Genomes. Bios Scientific Publ.13.Tamarin RH. 1999. Principles of Genetics. Wm C Brown Publ.
- Griffiths AJF. 2000. An Introduction to Genetic Analysis. WH Freeman.
- Hexter W & Yost HT. 1976.The Science of Genetics.Prentice Hall.
- Singer M & Berg P.1991.Genes and Genomes.John Wiley & Sons.
- Hartl DL & Jones EW. 1998. Genetics Principles and Analysis. Jones &Barlett Publ.
- Micklos DA &Freyer G. 2003.DNA Science - A First Course.CPL Scientific Publ.
- Brooker RJ. 2004. Genetics Analysis and Principles. Addison-Wesley Longman.
- Watson JD. 2004. Molecular Bilology of the Gene. Pearson Edu.

ABT 106: Plant Tissue Culture (2+1)

credits Theory: 2 Credits/ 36hours

Course Objectives:

The objective of this course is to deal with the principles, technical requirements, scientific and commercial applications of plant tissue culture. To expose to various supporting methodologies of plant tissue culture, micro propagation techniques and applications of plant tissue culture to crop improvement.

Student Learning Outcomes: On completion of this course, students should be able to:

- To understand the concepts and principles of plant tissue culture.

- Learning and monitoring different techniques of sterilization, different pathways of plant regeneration under invitro conditions- organogenesis and somatic

embryogenesis.

- Understanding the techniques of virus elimination- methods of virus indexing. Meristem and shoot tip culture and its applications
- Culturing of reproductive structures-anther, microspores, embryos, endosperm, ovule and ovary cultures and methods to produce haploids.

Syllabus:

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. **10hours**

2. Organogenesis (direct and indirect), Embryogenesis (direct and indirect), Somaclonal and gametoclonal variation, somatic embryos and artificial seeds-Cryo preservation. **8hours**

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. **18hours**

Practical: 1 Credit/ 18 hours

1. Laboratory setup; Sterilization of glass goods, plastic wares, media and plant materials **2hours**
2. Formulation and preparation of media for shoot androot initiation. **1 hours**
3. Fresh Cultureformicropropagation; Subculturing **2 hours**
4. Direct organogenesis using suitable explants. **3hours**
5. Indirect organogenesis usingsuitableexplants **3hours**
6. Suspension culture development from calli; Somatic embryogenesis from calli. **2hours**
7. Embryo culture, Anther culture; Preparation of competent cell. **2 hours**
8. Cloning of DNA. **3hours**

Recommended Textbooks:

- Bhojwani, S. S. (1990). Plant Tissue Culture: Applications and Limitations,Elsevier, Amsterdam.
- Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles andApplications of Recombinant DNA. Washington, D.C.: ASM Press.
- Singh, B. D. (2007). Biotechnology: Expanding Horizons. Kalyani Publishers.
- Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
- Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH:Science.

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

Course Objectives: The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of

communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes: Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;

- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.

Semester-IV [Total: 0 (T) + 25 (P) = 25 credits]

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

Course Objectives: The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes: Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results
- Learn how to present and explain their research findings to the audience effectively.

GPB 402: Project work (0+24) credits

Course Objectives: The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art ofanalysis and thesis writing.

Student Learning Outcomes: Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research;
- Capability to critically and systematically integrateknowledge to identify issues that must be addressedwithin framework of specific thesis;
- Competence in research design and planning;
- Capability to create, analyse and critically evaluate different technical solutions;
- Ability to conduct research independently;
- Ability to perform analytical techniques/experimental methods;

- Project management skills;
- Report writing skills;

- Problem solving skills;
- Communication and interpersonal skills.

Optional/ SpecialPapers

GPB 501: Introduction To Bioinformatics (3+1)
credits Theory: 3 Credits/ 54 hours

Course Objectives: The objective of the course to impart an introductory knowledge about the subject of Bioinformatics to the students studying any discipline of science.

Student Learning Outcomes: Students should be able to

- To get introduced to the basic concepts of bioinformatics and its significance in biological data analysis.
- Describe the history, scope and importance of Bioinformatics and role of internet in Bioinformatics.
- Classify different types of Biological Databases.
- Introduce to the basics of sequence alignment and analysis.

Syllabus:

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. **20 hours**

Unit-II
Introduction to database management and DBMS. Introduction to Perl and Bioperl. **8 hours**

Unit-III
Phylogenetic prediction: Phylogeny and sequence variations; concept of evolutionary trees; methods in phylogeny-maximum parsimony, distance methods, maximum likelihood, reliability of prediction. **8 hours**

Unit-IV
Gene prediction: Gene structure and characteristics; ORF; methods for microbial and Eukaryotic gene predictions. Internet Resources. **8 hours**

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

proteomics; synteny, functional genomics. **10 hours**

Practical: 1 Credit/ 18 hours

Sequence searching and alignment, writing programs in Perl for bioinformatics

Recommended Textbooks:

- Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. ColdSpring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford UniversityPress.
- Campbell AM and Heyer LJ (2007) Discovering Genomics, Proteomics andBioinformatics. Benjamin Cummings.

GPB502: Diversity Analysis (2+1) credits

Theory: 2 Credits/ 36 hours

Course Objectives: The objective of this course to expose students to various aspects of genetic diversity, its measurement, grouping and study of phylogenetic relationship.

Student Learning Outcomes: Students should be able to

- Acquaint with meaning of diversity, its importance and assessment.
- Learn different techniques of measuring the diversity, diversity indices, techniques for clustering etc.
- Familiarize various clustering softwares.
- Understand the concept phylogenetic relationship between evolution and diversity.

Syllabus:

UNIT-I
The meaning of diversity, history, importance and its use in agriculture. Assessment of diversity: Morphological, biochemical and molecular. **8 hours**

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. **12 hours**

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. NTSYSetc.)
8 hours

UNIT-IV
Collection of germplasm diversity, required sample size and introduction to various germplasm sampling models, Spatial tools for studying plant germplasm diversity. **8 hours**

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. **18 hours**

Recommended Textbooks:

- Philip W Hedrick. 2005. Genetics of Populations. Jones & Bartlett Publishers. USA.
- Sapra R L, Prem Narayan, S V S Chauhan, S K Lal and B B Singh. 2003. Sample size forcollecting germplasms- a polyplody model with mixed mating system. J Biosci.28 (2):155-161.
- Weir D S. 1990.Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.

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

credits Theory: 2 Credits/ 36hours

Course Objectives: To understand recent advances in improving quality traits in cereals, millets, legumes, oilseeds and forage crops by conventional and modern approaches.

Student Learning Outcomes: Students should be able to

- Learn about improvement of quality traits in rice, millets,legumes, oilseeds and forage crops;
- Understand molecular and cytogenetic manipulation for quality improvement;
- Understand genetic engineering protocols for quality improvement

Syllabus:

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. **8 hours**

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. **8 hours**

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. **8 hours**

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. **8 hours**

Unit-V

Genetic engineering protocols for quality improvement – Achievements made - Value addition in

crops; classification and importance-Nutritional genomics and Second generation transgenics.
4 hours

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. **18 hours**

Recommended Textbooks:

- Chahal G.S. and S.S. Ghosal. 2002. Principles and procedures of plant breeding – Biotechnological and Conventional approaches. Narosa Publications.
- Chopra, V.L. 1997. Plant breeding. Oxford and IBH Publishing Company.
- Jafar, Nigam. 1996. Genetic improvement of oilseed crops. Oxford and IBH Publishing Co.
- Ghosh, Premamoy. 2004. Fibre Science and Technology. Tata McGraw Hill Publishers.
- Singh, B.D. 1997 Plant breeding.Kalyani Publishers.
- Singh, R.K., Singh, U.K. and Khush, G.S. 2000.Aromatic rices. Oxford IBH Publishers.
- Specialityrices of the World – Breeding, production and marketing. 2001. FAO Oxford IBH.
- Hay Robvert, K. 2006. Physiology of Crop Yield.2nd Ed. Blackwell.

GPB602: Genomics and Proteomics

(2+0)credits Theory: 2 Credits/ 36hours

Course Objectives:

The objective of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.

Student Learning Outcomes: Students should be able to

acquire knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.

Syllabus:

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’sand 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, protein 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 andindustry. **8 hours**

Recommended Textbooks:

- Brown, TA. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
- Old, R.W.; Primrose, S.B.; & Twyman, R.M.; (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
- Campbell AM and Heyer LJ (2007) Discovering Genomics, Proteomics andBioinformatics. Benjamin Cummings
- Twyman RM. (2013) Principles of Proteomics.Second Edition by GarlandScience Taylor & Francis Group New York and London.