KURUKSHETRA UNIVERSITY KURUKSHETRA

(Established by the State Legislature Act-XII of 1956)
('A^{++}' Grade, NAAC Accredited)

Syllabus
for
Under-Graduate Programme

Subject: Genetics (Scheme – A)
Semesters V to VI

With Multiple Entry-Exit, Internship and CBCS-LOCF in accordance to NEP-2020 w.e.f. 2025-26

<table>
<tr><th colspan="4">Session: 2025-26</th></tr>
<tr><th colspan="4">Part A - Introduction</th></tr>
<tr><td>Subject</td><td colspan="3">GENETICS</td></tr>
<tr><td>Semester</td><td colspan="3">V</td></tr>
<tr><td>Name of the Course</td><td colspan="3">POPULATION AND EVOLUTIONARY GENETICS</td></tr>
<tr><td>Course Code</td><td colspan="3">B23-GEN-501</td></tr>
<tr><td>Course Type:
(CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)</td><td colspan="3">CC-5/MCC-9</td></tr>
<tr><td>Level of the course (As per Annexure-I</td><td colspan="3">300-399</td></tr>
<tr><td>Pre-requisite for the course (if any)</td><td colspan="3">Nil</td></tr>
<tr><td>Course Learning Outcomes (CLOs)</td><td colspan="3">After completing the course learner will be able to:
1. Basic understanding of population genetics and Evolution.
2. Students will acquire knowledge about the process of population dynamics and different factors controlling the evolution in context of genetics.
3. Understanding basic concepts of Genetics of Speciation.
4. Understanding phylogentic evolution using tools of Bioinformatics.
5. * Students will be able to understand the practical application of bioinformatics tools in the field of population and evolutionary genetics</td></tr>
<tr><td rowspan="2">Credits</td><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>3</td><td>1</td><td>4</td></tr>
<tr><td>Contact Hours</td><td>3</td><td>2</td><td>5</td></tr>
<tr><th colspan="4">THEORY</th></tr>
<tr><td colspan="2">Max. Marks: 70
Internal Assessment Marks: 20
End Term Exam Marks: 50</td><td colspan="2">Time: 3 hours</td></tr>
<tr><th colspan="4">PRACTICAL</th></tr>
<tr><td colspan="2">Max. Marks: 30
Internal Assessment Marks: 10
End Term Exam Marks: 20</td><td colspan="2">Time: 4 hours</td></tr>
</table>

Part B- Contents of the Course

Instructions for Paper- Setter

1. Nine questions will be set in all. All questions will carry equal marks.
2. Question No.1 will be a short answer type covering the entire syllabus and will be compulsory. The remaining eight questions will be set unit wise, selecting two questions from each unit. The candidate will be required to attempt question No. 1 and four more questions selecting one question from each unit.

Unit	Topics	Contact Hours
I	**Basic Concepts:** • Population genetics: Definition & Meaning, Mendelian Population and scope of population genetics. Gene and genotype frequencies, Mating patterns, Random & Non-random mating– positive & negative assortative mating, role in population size & change in gene frequency. • Hardy-Weinberg method & its applications– calculating allelic frequencies, assumptions of Hardy-Weinberg equilibrium, proof of Hardy-Weinberg equilibrium, Generation time, testing for fit to Hardy-Weinberg equilibrium. • Random Genetic drift– definition, its effects in small & large populations, bottlenecking & founder effect, genetic drift simulation, genetic drift vs. selection.	11
II	**Selection and Speciation:** • Genetic equilibrium– definition, conditions for its stability, deviation of it (evolution). Selection– overview, types & subtypes, negative & positive selections, patterns and mechanism of selection (stabilizing, disruptive, directional, balancing, disassortative sexual selection, frequency dependent selection), over dominance, natural selection, artificial selection, ecological selection. • Genetics of Speciation- Patterns and processes of speciation: Reproductive isolating barriers, Species concepts, Genetics of reproductive isolation and species, Natural hybridization	11

III	**Theories of Evolution:** • Emergence of theory of Evolution– Lamarckian evolution theory, Darwin's theory of evolution, Neo-Darwinism, modern synthesis theory of evolution, Macroevolution & Microevolution. • Evolution of Genetic Diversity- natural variation, sources of genetic variation: chromosomes & crossing over, SNPs, mutation, deletion & rearrangements, recombination, gene flow.	11
IV	**Molecular Basis of Evolution:** • Molecular Evolution– general approaches, principles, rates of molecular evolution, Evolution of eukaryotic genome structure, Gene family, evolution and phylo-genetics, • Protein and nucleotide sequence analysis and construction of phylogenetic tree using tools of Bioinformatics.	12
V*	**List of Practicals:** • Study of population genetics problems- Population Genetics Gene and Genotype Frequencies, Heritability and Polygenic variance (Min 3 problems in each) • Experiments on natural selection, male selection, female selection, genetic drift- Population size, sampling error • Study and construction of phylogenetic tree using Bioinformatics tools. • Project related to Genetics such as: Cytogenetics, Molecular, Microbial, quantitative, population and evolutionary Genetics	30

Suggested Evaluation Methods	
Internal Assessment: ➢ **Theory** ·Class Participation: 05 ·Seminar/presentation/assignment/quiz/class test etc.: 05 ·Mid-Term Exam: 10 ➢ **Practicum** ·Class Participation: - NA ·Seminar/Demonstration/Viva-voce/Lab records etc.: 10 ·Mid-Term Exam: NA	**End Term Examination:** Theory : 50 Practical : 20

Part C-Learning Resources

Recommended Books/e-resources/LMS:

- Gillespie, J. H. 2004 Population Genetics, a concise guide. 2nd Edition. The John Hopkins University Press.
- Nei, M. and S. Kumar. 2000. Molecular evolution and phylogenetics. Oxford University Press.
- Maynard Smith, J. 1989. Evolutionary genetics. Oxford University Press.
- Hedrick, P. W. 2000. Genetics of populations. 2nd Ed. Jones and Bartlett.
- Hartl, D. L. and A. G. Clark. 1997. Principles of population genetics. 3rd Ed. Sinauer.
- Snustad, D.P., and Simmons, M.J. (2003): Principles of Genetics, 3 Edn. John Wiley and Sons, inc. N.Y.
- Strickberger, M.W. (1996); Evolution, 2ndEdn. Jones and Barlett Pub. London.

Session: 2025-26			
Part A - Introduction			
Subject	GENETICS		
Semester	VI		
Name of the Course	AGRICULTURAL GENETICS		
Course Code	B23-GEN-601		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	CC-6/MCC-11		
Level of the course (As per Annexure-I	300-399		
Pre-requisite for the course (if any)	Nil		
Course Learning Outcomes (CLOs)	After completing the course learner will be able to: 1. Understand advanced concepts of population genetics and their role in crop evolution and adaptation. 2. Analyze chromosomal variations and their application in plant breeding and speciation. 3. Apply functional genomics and epigenetics to study gene regulation in stress and development. 4. Utilize molecular breeding tools like GWAS, genomic selection, and CRISPR in crop improvement. 5. * Perform advanced genetic and genomic techniques using bioinformatics tools in practical applications.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours	3	2	5
THEORY			
Max. Marks: 70 **Internal Assessment Marks:** 20 **End Term Exam Marks:** 50	**Time:** 3 hours		
PRACTICAL			
Max. Marks: 30 **Internal Assessment Marks:** 10 **End Term Exam Marks:** 20	**Time:** 4 hours		

Part B- Contents of the Course

Instructions for Paper- Setter

1. Nine questions will be set in all. All questions will carry equal marks.
2. Question No.1 will be a short answer type covering the entire syllabus and will be compulsory. The remaining eight questions will be set unit wise, selecting two questions from each unit. The candidate will be required to attempt question No. 1 and four more questions selecting one question from each unit.

Unit	Topics	Contact Hours
I	**Advanced Concepts in Classical Genetics** • Evolution of genetic theory: From Mendel to molecular genetics • Complex gene interactions: Polygenic inheritance, epistasis networks, gene modifiers • Molecular basis of dominance and overdominance • Quantitative Trait Loci (QTL): Concept, detection and significance	11
II	**Cytogenetics and Chromosomal Study** • Structural and numerical chromosomal variations in crop species • Cytogenetic basis of hybrid sterility and wide crosses • Alien gene introgression: Monosomics, nullisomics, trisomics • Aneuploidy and euploidy in crop improvement (wheat, cotton, banana case studies)	11
III	**Functional Genomics and Regulatory Networks** • Functional genomics in crop plants: Gene knockout, RNAi, TILLING, CRISPR/Cas systems • Transcriptome profiling and analysis of gene expression under stress • Small RNAs (miRNA, siRNA) and their role in trait regulation • Epigenetic mechanisms: DNA methylation, histone modification, chromatin remodeling	11

Part B- Contents of the Course		
IV	**Biotechnology in Crop Improvement** • Brief account of Plant Tissue culture technique, Embryo culture, meristem culture and anther culture. • Brief account of research centres International Rice Research Institute (IRRI), Sugarcane Breeding Institute (SBI), Central Potato Research Institute(CPRI), Central Institute of Cotton Research (CICR), International Center for Improvement of Maize and Wheat (CIMMYT)	12
V*	**List of Practicals:** □ Isolation of high-quality genomic DNA and quantification (NanoDrop/Qubit) □ PCR-based marker analysis: SSR, SNP genotyping using PAGE and capillary electrophoresis □ CRISPR guide RNA design and in silico editing simulation □ RNA isolation and RT-qPCR analysis for gene expression profiling □ Population structure analysis using STRUCTURE and PCA (genotypic data) □ Linkage map construction and QTL analysis using software (e.g., QTL Cartographer, R/qtl) □ Genomic selection model construction using R packages (rrBLUP, BGLR) □ Functional annotation of genes using transcriptomic datasets	30
Suggested Evaluation Methods		
Internal Assessment: ➢ **Theory** ·Class Participation: 05 ·Seminar/presentation/assignment/quiz/class test etc.: 05 ·Mid-Term Exam: 10 ➢ **Practicum** ·Class Participation: - ·Seminar/Demonstration/Viva-voce/Lab records etc.: 10 ·Mid-Term Exam: NA		**End Term Examination:** Theory : 50 Practical : 20

Part C-Learning Resources

Recommended Books/e-resources/LMS:

- Russell, P. J. (2017). *Genetics* (8th ed.). Pearson Education.
- Snustad, D. P., & Simmons, M. J. (2015). *Principles of Genetics* (7th ed.). Wiley.
- Falconer, D. S., & Mackay, T. F. C. (1996). *Introduction to Quantitative Genetics* (4th ed.). Longman.
- Gillespie, J. H. (2004). *Population Genetics: A Concise Guide* (2nd ed.). Johns Hopkins University Press.
- Singh, R. J. (2002). *Plant Cytogenetics* (2nd ed.). CRC Press.
- Gupta, P. K., & Tsuchiya, T. (Eds.). (1991). *Chromosome Engineering in Plants: Genetics, Breeding, Evolution*. Elsevier.
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene* (7th ed.). Pearson.
- Brown, T. A. (2017). *Genomes 4*. Garland Science.
- Brownstein, M. J., & Khodursky, A. B. (Eds.). (2007). *Functional Genomics: Methods and Protocols* (2nd ed.). Humana Press.
- Chahal, G. S., & Gosal, S. S. (2002). *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa Publishing House.
- Varshney, R. K., & Tuberosa, R. (Eds.). (2007). *Genomics-Assisted Crop Improvement: Vol. 1 – Genomics Approaches and Platforms; Vol. 2 – Genomics Applications in Crops*. Springer.
- Lamkey, K. R., & Lee, M. (Eds.). (2006). *Plant Breeding: The Arnel R. Hallauer International Symposium*. Blackwell Publishing.
- Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis* (2nd ed.). Cold Spring Harbor Laboratory Press.
- Selzer, P. M., & Marhöfer, R. J. (2006). *Applied Bioinformatics: An Introduction* (2nd ed.). Springer.