Course title: Genome Structure and Diversity: Concepts and Methodologies			
Course code: BBP167	**No. of credits:** 3	**L-T-P:** 23-22-0	**Learning hours**: 45
Pre-requisite course code and title (if any): None			
Faculty: Anandita Singh	**Department:** Department of Biotechnology		
Course coordinator(s):	**Course instructor(s):**		
Contact details:			
Course type: Core	**Course offered in:** Semester 2		

Course description:

Organismal diversity in tree of life is strident evidence of how evolutionary events have shaped the architecture of genomes and its constituents leading to origin of extant species. Genome elucidation studies are essential for understanding the fine link between genes, genomes, and morphological variation. This advanced course provides a theoretical framework on genome variability across life forms with respect to genome content, complexity, organization and experimental methods used for genome analyses. Students will learn about traditional and modern marker techniques routinely employed in R&D laboratories. Application of DNA marker based genotyping techniques will be illustrated using relevant cases studies. Students will also be undertaking a critical appraisal of various marker techniques with respect to cost and relative efficiencies towards rational deployment in projects and research programmes. In the first module, students will gain insights on characteristic features of prokaryotic and eukaryotic genomes. In the second module, students will be introduced to genotyping tools for polymorphism screening and detection. Introduction to next generation, genomics based, genotyping platforms will sensitize the students to frontier areas of research. In third module, application of genotyping and marker techniques will be discussed, mainly in context to agriculture, biomedical and healthcare sector. Through this course, students will gain a holistic perspective on "genotype-phenotype association" and will be able to integrate core principles of such disciplines as molecular genetics, genomics and evolution.

Course objectives:

1. Building perspectives on structure and variability in genomes and its constituents
2. Illustrating the relationship between genotypic and phenotypic variation
3. Introducing versatile methodologies, concepts and applications of molecular marker techniques

Course contents

Module 1	**Variability in Genome Structure and Organization**	**L**	**T**	**P**
1	**Genome diversity:** Genome sizes and complexity, C-Value paradox, Unique and repeat DNA sequences; Tandem and Interspersed repeats, Mobile Elements, Micro- and Mini-satellites, hyper-variable VNTRs, Genome Evolution, DNA rearrangements, SNPs and Structural variations, Inversions, Insertion and Deletions; **Variability in genes and regulatory elements:** Protein coding and non-coding genes, Intron-less, interrupted, poly-cistronic and overlapping genes; Structure and function of cis-regulatory elements (promoters, enhancers, insulators, terminators); **Hierarchies of Genome Organization** (Genomic sequences, chromatin, nucleosomes, packaging)	6	6	
Module 2	**Genome Elucidation by Molecular Markers**			
2	**Molecular Markers and DNA fingerprinting Techniques** Introduction to Dominant and co-dominant markers; Restriction Fragment Length Polymorphism, MAAP (Multiple Arbitrary Amplicon Profiling) and other PCR based markers (DNA Amplification Fingerprinting, Arbitrarily Primed PCR, Randomly Amplified Polymorphic DNA, SSRs, STMS, SCARs, Inter-SSRs, Amplified Fragment Length Polymorphism, Selectively Amplified Microsatellite Polymorphic Loci, Inter retrotransposon amplified polymorphism, retrotransposon-microsatellite amplified polymorphism, Intron spanning markers, SNP based marker assays (CAPs, dCAPs, dHPLC, molecular beacons, 5'nuclease assay/TaqMan assays, FEN based Invader reactions), Eco-TILLING (Targeting	12	12	

	induced local lesions in the genome); **Modern Genotyping platforms:** Array based genotyping (Affymetrix axiom, Affymetrix genechip, Illumina Infinium Bead Chip; NGS based genotyping methods (GBS, DArT-seq, RAD-seq, ddRAD, REST-seq); de-novo sequencing (PacBio. HiC. 10X Chromium, Oxford nanopore, HiSeq4000/NovaSeq6000, IonTorrent)			
Module 3	**Applications and Case studies of Marker Technology**			
3	**Diversity analysis:** Numerical taxonomy and phenetics, genotyping for conservation of plant genetic resources; **Molecular Breeding:** Genetic mapping, Mapping Populations, Marker Assisted Selection, Positional Cloning, Genomics Assisted Breeding; Plant Variety Protection; GWAS; **Diagnostics:** Human diseases, risk prediction, discovery of drug targets and improving healthcare, DNA barcoding, hybrid purity tests, clonal fidelity	5	4	
	Total	**23**	**22**	

Evaluation criteria:

1. Test 1: 40%
2. Test 2: 60%

Learning outcomes:

1. An understanding on structure and variability in genomes and its constituents **(Test 1-2)**
2. Ability to rationalize deployment of genotyping techniques for relevant applications **(Test 1-2)**
3. Understanding genetic and molecular basis of phenotypic variation **(Test 1-2)**

Pedagogical Approach:

Lectures and tutorials in online or offline mode with a major emphasis on the detailed discussion of original research articles

Skill Set:

1. Generating and interpreting DNA fingerprints and profiles for forensics
2. Developing natural and synthetic microbiomes as biofertilizers, biopesticides, healthcare products
3. Testing Hybrid purity
4. Diagnosing varieties, cultivars, accessions and land races
5. Ascertaining clonal fidelity for tissue culture raised regenerants
6. Applying MAS (Marker Assisted Selection) strategies in breeding programmes
7. Introducing transgenes for development of new plant varieties
8. DNA bar-coding technology
9. Evaluating gene-flow in transgenic field trials
10. Formulating appropriate conservation strategies
11. Innovating genome interrogation methods for unarticulated research problems

Employability:

1. Forensic Science laboratories, molecular diagnostic testing laboratories
2. Genotyping and sequencing companies
3. Agri-biotechnology and seed companies
4. Tissue culture and horticulture companies
5. Law firms and knowledge processing organizations (IP management consultancy)
6. Regulatory bodies and funding agencies

Materials:

Suggested readings (Representative)

1. Carroll, S. B., Grenier, J. K., & Weatherbee, S. D. (2004). *From DNA to diversity: Molecular genetics and the evolution of animal design* (2nd ed.). Wiley-Blackwell. ISBN: 978-1-4051-1950-4.
2. Krieg, N. R., Ludwig, W., Whitman, W. B., Hedlund, B. P., Paster, B. J., Staley, J. T., Ward, N., & Brown, D.

(Eds.). (2010). *Bergey's manual of systematic bacteriology* (2nd ed., Vol. 4). Springer-Verlag, New York, NY.
3. Dale, J. W., von Schantz, M., & Plant, N. (2011). *From genes to genomes: Concepts and applications of DNA technology* (3rd ed.). John Wiley & Sons, UK.
4. Brown, T. A. (2017). *Genomes 4*. CRC Press, Taylor & Francis Group, USA.
5. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's GENES XII*. Jones & Bartlett Learning, USA.
6. Meksem, K., & Kahl, G. (2005). *The handbook of plant genome mapping: Genetic and physical mapping*. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim.
7. Varshney, R. K., Pandey, M. K., & Chitikineni, A. (2018). *Plant genetics and molecular biology*. Advances in Biochemical Engineering/Biotechnology Series (Vol. 164). Springer Nature, Switzerland.
8. Varshney, R. K., Roorkiwal, M., & Sorrells, M. E. (2017). *Genomic selection for crop improvement: New molecular breeding strategies*. Springer Nature, Switzerland.
9. Scherer, S., & Visscher, P. (2016). *Genome-wide association studies: From polymorphism to personalized medicine* (K. Appasani, Ed.). Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781107337459

Student responsibilities:
1. Class attendance
2. Study of course materials as specified by the instructor
3. Self-study

Course reviewers:

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