

**TWO YEAR
MASTERS IN GENETICS
POST GRADUATE PROGRAMME
Semester 3 & 4 (**Structure 1**)**



**DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS**

MSC GENETICS – TWO YEAR DEGREE PROGRAM

Course Structure and Credits Overview

Students enter into this program after three years of graduation from any discipline in Science through an entrance exam only. **After completion of their one year (Semester 1 & 2), which is exactly the same for all 2 year PG students-** they will enter into three possible Structures in their second year (Semester 3 & 4) as prescribed by the University.

Their entry into these Structures will be in consultation with the Department based on available infrastructure, facilities and teaching faculty. These structures have been prescribed based on the distribution of core (C), elective (E), 2 credit course skill based course (2c/SBC) and research project (R) component. Our department has been keeping experimental training in the forefront of our Masters programs enabling our students to seek research as a career option. Therefore, we have incorporated our experimental training based on the theory being taught as a Core subject wherever permissible. The credits under each course type are divided into Theory/Lecture (L), Practical (P) and Tutorial (T) as per the norms shared by the University. The division is shown along with the course content of every semester.

1 credit = 15 hours of teaching/30 hours of practical/15 hours of tutorials

Distribution Of Course Type Credits Under Each Structure When The Students Exit Msc Genetics (2Y) Program

	Core	Elective	2 credit courses	Research project	Credits earned at exit of MSc-2Y PG
Structure 1	40	40	8	0	88
Structure 2	40	32	4	12	88
Structure 3	28	24	10	26	88

Overview Of The Structures Available To Msc. Genetics (2Y Program) – Semester-Wise Distribution

	Semester 1 (same courses for all)				Semester 2 (same courses for all)				Semester 3				Semester 4				Total credits
	C	E	2c	R	C	E	2c	R	C	E	2c	R	C	E	2c	R	
Structure 1	12	8	2	0	12	8	2	0	8	12	2	0	8	12	2	0	88
Structure 2	12	8	2	0	12	8	2	0	8	8	0	6	8	8	0	6	88
Structure 3	12	8	2	0	12	8	2	0	4	4	4	10	0	4	2	16	88

C: Core; E: Elective (Discipline specific/Open); 2c (2 credit core courses); R: Research project

Note regarding Electives:

Elective courses are either Discipline specific elective (DSE, offered by the department of genetics) or general elective (GE, offered by other departments) Students can either opt for all DSE offered by its own department or opt for ANY ONE of the GE by other department in addition to other DSE(s) to complete their quota of electives in a particular semester.

Two year MSc Genetics, 2Y-PG

Structure 1(Coursework)

Course Code	Type/credit	Title	
Semester 1			
DSC-GEN-101	DSC/4	Biological Processes and Patterns of Inheritance	Compulsory
DSC-GEN-102	DSC/4	Genes, Genome and Chromosomes	
DSC-GEN-103	DSC/4	Experiential learning in Genetics- I	
DSE-GEN-104	DSE/4	Molecular Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-105	DSE/4	Cell Biology	
DSE-GEN-106	DSE/4	Enzymology and Metabolism	
GE-GEN-110	GE/4	Genetics in Crop Improvement (offered only to students of other departments)	
SBC-GEN-111	SBC/2	Statistical Analysis in Biology	Compulsory
Semester 2			
DSC-GEN-201	DSC/4	Regulation of Gene Expression	Compulsory
DSC-GEN-202	DSC/4	Recombinant DNA Technology	
DSC-GEN-203	DSC/4	Experiential learning in Genetics- II	
DSE-GEN-204	DSE/4	Developmental Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-205	DSE/4	Immunology and Immunogenetics	
DSE-GEN-206	DSE/4	Mitochondrial Biology and Connection to Cell Physiology	
GE-GEN-210	GE/4	Genetics in Everyday Life: From DNA to Society (offered only to students of other departments)	
SBC-GEN-211	2CC/2	Microscopy and Imaging	Compulsory
Semester 3			
DSC-GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
DSC-GEN-302	DSC/4	Experiential learning in Genetics – III	
DSE-GEN-303	DSE/4	Genetics of Microorganisms	Option of any 3 DSE or 2 DSE+1 GE (GE offered by other departments)
DSE-GEN-304	DSE/4	Plant Genetics and Breeding	
DSE-GEN-305	DSE/4	Human Genetics	
GE-GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
SBC-GEN-311	2CC/2	Advanced Research Methodology	Compulsory
Semester 4			
DSC-GEN-401	DSC/4	Population and Quantitative Genetics	Compulsory
DSC-GEN-402	DSC/4	Application of genetic studies in clinical research and plant biotechnology	
DSE-GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 3 DSE or 2 DSE+1 GE (GE offered by other departments)
DSE-GEN-404	DSE/4	Biology of Dictyostelium	
DSE-GEN-405	DSE/4	Cancer Biology and Genetics	
DSE-GEN-406	DSE/4	Molecular plant-microbe interaction	
DSE-GEN-407	DSE/4	Yeast genetics	
GE-GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
SBC-GEN-411	2CC/2	Scientific Writing and Presentation	Compulsory

SEMESTER 3 (2Y-PG)

Structure 1-Coursework

Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	2	3 (3DSE+0GE; 2DSE+1GE)	1	0	6
Credits	8	12	2	0	22
Student needs to complete $8+12+2+0 = 22$ credits					

Course Distribution and Overview

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSC-GEN-301	DSC	Principles of Genetic analysis	4	3	1	0
DSC-GEN-302	DSC	Experiential Learning in Genetics - III	4	0	4	0
DSE-GEN-303	DSE	Genetics of microorganisms	4	3	0	1
DSE-GEN-304	DSE	Plant Genetics & Breeding	4	3	0	1
DSE-GEN-305	DSE	Human Genetics	4	3	0	1
GE-GEN-310	GE	Genetics in Human Health	4	3	0	1
SBC-GEN-311	SBC	Advanced Research Methodology	2	1	1	0

1 credit = 15 hours of teaching/ 30 hours of practical/ 15 hours of tutorials

DSC-GEN-301

Principles of Genetic Analysis

Course Objective: The paper on Genetic Analysis builds upon the foundation laid by Biological Processes and Inheritance Patterns, taught in Semester I, or equivalent courses from undergraduate programs in the four-year curriculum. Unit 1 is structured to reinforce the fundamental concepts of genetic analysis introduced earlier, with a strong emphasis on self-reading and assignments to deepen understanding. Recognizing the diverse methodologies available for genetic analysis in different organisms the subsequent units 2 and 3 focus on outlining essential concepts rather than detailing specific analytical instances. These topics will be enriched with case studies, and the mentor will select the specific examples most relevant for discussion. Unit 4 is introductory in nature and will be covered in details in other papers.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-301 Principles of Genetic Analysis	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Recap of key concepts	8
II	Power of genetic analysis	20
III	Of maps and distances	10
IV	Genes and Populations	7
Practical		
I	Studying inheritance in bacteria through conjugation	15
II	Studying inheritance in eukaryotes using appropriate model system	15

Course outcomes : On completing ‘Principles of genetic analysis’, the students would have:

- Developed a strong conceptual foundation in genetic variation and inheritance patterns
- Gained an understanding of how genetic analysis is employed in different model systems to reveal gene function and biological pathways
- Learned how mutations are generated, identified and analyzed to connect phenotypes with underlying genes.
- Understood the principles and purpose of genetic and physical mapping in locating genes and interpreting recombination.
- Acquired insight into the genetic analysis of populations and complex traits using natural variation and genome-wide approaches.

Content (Theory)**45 hours****I. Recap of key concepts (8 hours)**

- Variations : key to genetic analysis
- Cellular and Molecular basis of inheritance patterns
- Epistasis and Genetic pathways
- Probability and statistics in genetic analysis
- Societal impact of genetics

II. Power of genetic analysis (20 hours)

- Pros and cons of different systems: e.g. Viruses, bacteria, yeast, *C. elegans*, *Drosophila*, *Arabidopsis*, mouse, humans
- Mutations: Generating, finding and classifying mutants
- Assigning mutants to genes - complementation test
- Phenotype to DNA sequence – Forward Genetics
- Cloned genes to mutant phenotype – Reverse Genetics
- Genome-wide mutant screens

III. Of maps and distances (10 hours)

- The classical mapping strategy: Three-point test cross and fine structure mapping of genes- what do they teach us?
- Temporal and recombination maps
- Physical versus Genetic maps
- Mapping genes to chromosomes
- Why create maps ?

IV. Genes and Populations (7 hours)

- Genome wide associations
- Genetic analysis of complex traits
- Genetic analysis using natural variations

Content (Practical)**30 hours****I. Studying inheritance in bacteria through conjugation**

- Setting up crosses bacterial crosses using differing recipient strains of *E. coli*
- Recovery of ex-conjugates using media designed to screen for respective markers present in the donor
- Confirmation experiments of successful conjugation using F+ and F – strains of *E. coli*

II. Studying inheritance in eukaryotes using appropriate model system

- Students will be given experiential training in analyzing segregating population of *Arabidopsis*/ seeds to understand basic principal of independent assortment and segregation
- Statistical analysis of generated data (from above) using chi square test

Essential Reading

1.	Genetics: Analysis: Genes, genomes and Networks (Unit I, II, III, IV)	Meneely P	2 nd Edition Oxford University Press
2.	Introduction to Genetic Analysis (Unit I, II, III, IV)	Griffiths A JF et al	12 th Edition Macmillan International Higher Education

Suggested Reading

1.	Genetics: Principles and Analysis (Unit I, II, III, IV)	Hartl DL and Jones EW	Jones and Bartlett Publishers
2.	Concepts of Genetics (Unit I, II, III, IV)	Klug W, Cummings MR, Spencer CA, Palladino MA	Pearson Publishing
3.	Genetics of Bacteria (Unit II)	Srivastava S	Springer Nature
4.	Research papers as suggested by the teacher (Unit I, II, III, IV)		

SEMESTER 3; S1

DISCIPLINE SPECIFIC CORE

2Y-PG

DSC-GEN-302

Experiential learning in Genetics - III

Course Objective: *The objective of this course is to give the students an exposure to the different techniques used in human genetics, mapping genes and plant biotechnology, enrich their skills to carrying out independent experiments and analyze the results.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-302 Experiential learning in Genetics - III	4	0	0	4	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Mapping variations in genome		
I	Analysing variations in prokaryotes	30
II	Analysing variations in human genome	30
III	Mapping of variations in plant genome	30
IV	Modelling variations using bioinformatic tools	30

Course Outcome: By the end of this course, students will be able to:

- Think critically and solve problems – Ask scientific questions, design experiments, and troubleshoot challenges while working with UV mutagenesis and protein purification/characterisation
- Apply theory to practice – Use knowledge of microbial genetics and protein biochemistry in real experiments rather than just learning separate techniques.
- Analyse and interpret data – Collect, measure, and evaluate mutation frequencies, enzyme activity, and protein purification efficiency to draw meaningful conclusions.
- Improve scientific communication – Present findings clearly through reports, data visualization, and discussions, developing better communication skills.
- Adopt a research mindset – Learn to refine experiments, adapt methods, and explore new approaches, preparing for independent research in genetics and biochemistry.

Content (Practical)**120 hours**

- I. **Microbial experiments** (30 hours)
 - Isolation of lac constitutive mutants and their characterization (continued from Semester I)
 - Test the ability of WT and mutant strains of *S. cerevisiae* to utilize glycerol as the sole carbon source.
 - Test for the presence of mtDNA in the mutant *S. cerevisiae* strain Power of genetic analysis
- II. **Human genetics** (30 hours)
 - Modelling mendelian inheritance
 - Analysis of copy number alterations
 - DNA isolation from mammalian lymphocytes/cell-line
 - o Quantitative and qualitative analysis
 - o Genotyping with (a) Microsatellite markers and (b) SNPs
 - o Mutation screening by (a) PCR- RFLP and (b) PCR- sequencing
 - Cell free DNA fragment analysis from different human cancer cell lines
- III. **Mapping genes** (30 hours)
 - Linkage analysis with microsatellite markers and LOD score estimations
 - Diversity analysis using program NTSYS
 - Construction of linkage map using program JoinMap4
 - Demonstration of program used for QTL mapping
 - Field trip to plant breeding station
- IV. **Exercises based on bioinformatics** (30 hours)
 - Use of tools to predict protein features
 - Retrieve sequence of gene/protein from reference database (for example, GTPase, kinase or other enzymes required for cell growth)
 - Run sequence alignment
 - Develop phylogenetic tree

SEMESTER 3; S1

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-303

Genetics of Microorganisms

Course Objective: *Microorganisms have occupied a significant space in the field of not just genetics but also immunology and biochemistry. Combining the structural simplicity with the unifying genetic basis, they offered immediate advantages in studying all the three aspects of heredity: the generation, expression, and transmission of biological variation. This paper deals with the strength of microbial genetics: both prokaryotic as well as eukaryotic.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-303 Genetics of Microorganisms	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Classical genetics in microbes	10
II	Molecular genetics and tools	8
III	Art and design of genetic screens	18
IV	Quorum sensing and immunity in bacteria	9
Tutorials		
	Various modalities	15

Course outcomes : On completing 'Genetics of Microorganisms', the students would have:

- A clear understanding of how genes are transferred and mapped in bacteria and how bacteriophages contribute to genetic recombination and regulation.
- Working knowledge of molecular genetics tools using eukaryotic model microbe, yeast as a model system for identification gene function, cloning, expression control, and genome manipulation.
- The ability to design and interpret genetic screens to uncover gene function and genetic interactions in cellular pathways.
- An integrated understanding of quorum-sensing, bacterial signal transduction, biofilm formation and regulation, immune strategies in bacteria.
- Practical experience in genetic screening and inheritance analysis using yeast to distinguish nuclear and cytoplasmic genetic control.

Content (Theory)**45 hours**

- I. Classical Genetics in Microbes (10 hours)**
- Conjugation - Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination
 - Chromosome transfer in other bacteria
 - Transformation- Natural transformation systems, biology and mechanism of transformation, transformation and gene mapping, chemical-mediated and electro-transformation
 - Transduction: Discovery, generalized and specialized or restricted transduction, phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction;
 - Temperate phage lambda and mechanism of specialized transduction
 - Gene mapping, Fine-structure mapping
 - Techniques for studying bacteriophages- Virulent phage (T4) and temperate phage (phage lambda)
 - Important aspects of lytic cycle, phage-host relationships, immunity and repression site specific recombination (lambda and P1).
- II. Molecular genetics and tools (8 hours)**
- Yeast as an experimental system for eukaryotic molecular biology
 - Yeast cloning and expression vectors
 - Regulatable promoters
 - Construction of genetically modified strains
 - Generation of conditional alleles
 - Cosmids and yeast artificial chromosomes
 - Yeast one-, two- and three-hybrid systems
 - Mating-Type Genes and MAT Switching in *Saccharomyces cerevisiae*, HML, HMR and MAT loci, HO endonuclease, regulation of switching.
- III. Art and design of genetic screens (18 hours)**
- Choice of mutant phenotypes
 - Cloning by complementation
 - Isolation of bypass and allele specific-suppressors
 - Synthetic lethal screens
 - Use of these tools to isolate genes in the protein secretion pathway in yeast.
- IV. Quorum sensing and immunity in bacteria (9 hours)**
- Examples from *Vibrio harveyi* and *Vibrio fischeri*
 - Regulation of biofilm formation in *Vibrio cholera*
 - Two component signal transduction system
 - Discovery of CRISPR-Cas and its role in bacterial immunity.

- Content (Tutorial)**15 hours**

- Addressing individual queries on class concepts
- Discussing research papers on seminal work using genetic principles to understand protein secretion

- Secretion and cell-surface growth are blocked in a temperature-sensitive mutant of *Saccharomyces cerevisiae* doi: 10.1073/pnas.76.4.1858
- Order of events in the yeast secretory pathway doi: 10.1016/0092-8674(81)90064-7
- Cloning by complementation exemplified by identification of SEC14 gene (Rab Protein) doi: 10.1083/jcb.108.4.1271
- A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum doi: 10.1083/jcb.105.2.633
- **Discussing research papers on seminal work using genetic principles to understand quorum sensing**
 - Intercellular signalling in *Vibrio harveyi* doi: 10.1111/j.1365-2958.1993.tb01737.x.
 - Multiple signalling systems controlling expression of luminescence in *Vibrio harveyi* doi: 10.1111/j.1365-2958.1994.tb00422.x
- **Discussing research papers on seminal work using genetic principles to understand bacterial immunity**
 - CRISPR Provides Acquired Resistance Against Viruses in Prokaryotes doi: 10.1126/science.1138140
 - The CRISPR/Cas bacterial immune system cleaves bacteriophage and plasmid DNA doi: 10.1038/nature09523
 - A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity doi: 10.1126/science.1225829
 - The *Streptococcus thermophilus* CRISPR/Cas system provides immunity in *Escherichia coli* doi:10.1093/nar/gkr606
 - Cas9-crRNA ribonucleoprotein complex mediates specific DNA cleavage for adaptive immunity in bacteria doi:10.1073/pnas.1208507109
- **Discussing relevant video content exemplified by**
 - Nobel Prize Inspiration Initiative lecture by Laureate Randy <https://www.youtube.com/watch?v=Udg6bYkBtX8>
 - Cell-Cell Communication in Bacteria via Quorum Sensing <https://www.ibiology.org/microbiology/quorum-sensing/>
 - The CRISPR Apostle: Rodolphe Barrangou <https://www.ibiology.org/microbiology/crispr-apostle/>
 - Genome Engineering with CRISPR-Cas9: Birth of a Breakthrough Technology <https://www.ibiology.org/genetics-and-gene-regulation/crispr-cas9/>

Essential Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.

Suggested Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.
3.	Modern Microbial Genetics (Unit II, III)	Streips U N & Yasbin RE	Wiley-Liss
4.	Molecular Genetics of Bacteria (Unit I)	Sneider L & Champness W	ASM Publishers
5.	Genetics of Bacteria (Unit I)	Scaife J	Academic Press
6.	Genetics of Bacteria and Viruses (Unit I)	Birge EA	Springer
7.	Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit II, III)	Guthrie C & Fink GR (Eds.)	Elsevier

SEMESTER 3; S1 DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-304

Plant Genetics and Breeding

Course Objective: This course introduces students to the classical and contemporary principles of plant genetics and breeding. It covers natural breeding systems, gene pools, chromosome manipulation, heterosis, and conventional breeding strategies, while integrating advanced genomic and quantitative approaches, including QTL mapping, GWAS, genomic selection, phenomics, G×E analysis, and gene-editing-enabled breeding. The course is designed to provide a holistic understanding of how modern plant breeding combines genomics, statistics, and biotechnology to accelerate crop improvement and generate climate-resilient, high-yielding varieties.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-304 Plant Genetics and Breeding	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Historical perspective	4
II	Natural and conventional breeding strategies for trait introgression	13
III	Cytogenetic and chromosome manipulation approaches	5
IV	Molecular/genomics-assisted and heterosis breeding for crop improvement	23
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Plant Genetics and Breeding', the students would have:

- A clear understanding on tracing the historical development of plant breeding from early domestication to molecular and genomic eras and assess the importance of germplasm resources
- Learnt about Natural Breeding Systems, and Conventional Breeding Approaches
- Developed the aptitude for developing cytogenetic approaches and chromosome engineering
- Acquired the ability to apply basic concepts for molecular and genomics-assisted breeding

Content (Theory)**45 hours****I. Historical perspective (4 hours)**

- Importance and evolution of plant breeding.
- Major milestones: Mendelian genetics, chromosomal theory, quantitative genetics, Green Revolution, hybrid breeding.
- Transition from classical breeding to molecular and genomic eras.
- Role of genetic diversity and domestication in crop improvement.

II. Natural/conventional breeding methods and the gene pool concept (13 hours)

- Modes of reproduction in crop plants; self-pollination, cross-pollination, mixed mating, and apomixis.
- Consequences of breeding systems for homozygosity, heterozygosity, genetic load, and population structure.
- Applications of breeding systems in designing breeding strategies, including for climate-resilient cultivar development.
- Gene pool concept (primary, secondary, tertiary) and its relevance to trait introgression.
- Germplasm of major crops: cultivated types, landraces, wild relatives; pre-breeding strategies.
- Breeding methods for self-pollinated crops: mass selection, pure-line selection, pedigree method, bulk method, single-seed descent.
- Breeding methods for cross-pollinated crops: recurrent selection (simple, reciprocal, half-sib, full-sib), synthetic and composite varieties.
- Breeding vegetatively propagated crops: clonal selection and improvement strategies.

III. Cytogenetic and chromosome manipulation approaches (5 hours)

- Haploidy and doubled haploidy: production methods and use of DH lines in breeding.
- Polyploidy: auto- and allopolyploids, chromosome doubling, and applications in crop improvement.
- Wide hybridization: barriers to interspecific/intergeneric crosses and methods to overcome them (embryo rescue, ovule culture).
- Cytogenetic tools: karyotyping, meiotic pairing analysis, alien addition and substitution lines, induced translocations, and chromosome engineering.
- Applications of cytogenetic approaches in transferring stress-tolerance and other traits from wild relatives.

IV. Molecular/genomic and heterosis plant breeding (23 hours)

- Concepts and theories of heterosis at genetic, biochemical, and molecular levels.
- Combining ability (general and specific), heterotic groups and patterns.
- Hybrid breeding systems: CMS, GMS, TGMS; restorer lines; hybrid seed production technology.
- Molecular markers (SSR, SNP, indels): principles, strengths, limitations, and applications.
- Genetic linkage, mapping functions, and mapping populations (F_2 , RILs, NILs, DHs).
- Linkage mapping and QTL analysis: detection, effect estimation, and fine mapping.
- Association mapping/GWAS: linkage disequilibrium, population structure, and correction for confounding.

- Quantitative genetic parameters relevant to molecular/genomics-assisted breeding: heritability, genetic variances, and response to selection.
- Marker-assisted selection (MAS), marker-assisted backcrossing (MABC), and strategies for minimizing linkage drag; Marker-assisted recurrent selection (MARS) and gene pyramiding for complex traits.
- Genomic selection (GS) and genomic prediction: training populations, statistical models, validation, and deployment.
- Role of phenomics, multi-environment testing, and genotype × environment interactions in genomics-assisted breeding.
- Integration of gene editing (CRISPR/Cas), speed breeding, and high-throughput phenotyping into modern breeding pipelines.
- Use of integrative genomic approaches for developing climate-smart cultivars.

Content (Tutorial)

15 hours

- **Addressing individual queries and clarifying concepts from lectures.**
- **Discussion of classical and modern research papers in plant genetics and breeding (e.g., success stories of hybrid development, QTL mapping, MAS, and GS). These include, but are not limited to:**
 - Doebley, J. F., Gaut, B. S., & Smith, B. D. (2006). The molecular genetics of crop domestication. *Cell*, 127(7), 1309–1321. doi: 10.1016/j.cell.2006.12.006
 - Forster, B. P., & Thomas, W. T. B. (2005). Doubled haploids in genetics and plant breeding. *Plant Breeding Reviews*, 25, 57–88. doi: 10.1002/9780470650301.ch3
 - Meuwissen, T. H. E., Hayes, B. J., & Goddard, M. E. (2001). Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, 157(4), 1819–1829. doi:10.1093/genetics/157.4.1819
 - Yu, J., Pressoir, G., Briggs, W. H., et al. (2006). A unified mixed-model method for association mapping that accounts for multiple levels of relatedness. *Nature Genetics*, 38(2), 203–208. doi: 10.1038/ng1702
- **Problem-solving sessions on designing breeding schemes, calculating basic quantitative genetic parameters, and interpreting mapping results.**
- **Demonstrations (through published examples/videos) of phenotyping platforms and integration of molecular data in breeding decisions.**
 - Genetics is Shaping Agriculture and Food | https://www.ted.com/talks/sanushka_naidoo_genetics_is_shaping_agriculture_and_food
 - Breeding Climate-Resilient Crops | <https://www.youtube.com/watch?v=x9lxJcnZMoA>
 - How Technological Change Drives Improvement in Plant Breeding & Agriculture | <https://www.youtube.com/watch?v=bbr1HPNmF8>
 - Genotyping-by-Sequencing (GBS) Explained | <https://www.youtube.com/watch?v=jb7y1USeCBE>
 - What is Marker-Assisted Selection? (CIMMYT) | <https://www.youtube.com/watch?v=0uZcM2E-H2c>

- How Genomic Selection Works in Plant Breeding (CIMMYT) | <https://www.youtube.com/watch?v=pVY6gWgRVYo>
- CRISPR: Gene Editing in Agriculture (Broad Institute) | <https://www.youtube.com/watch?v=jAhjPd4uNFY>
- High-Throughput Plant Phenomics (LemnaTec) | <https://www.youtube.com/watch?v=v0rWb7YwN5o>
- Speed Breeding for Crop Improvement | <https://www.youtube.com/watch?v=c4kCgF5bT2E>

Essential Readings

Plant Breeding: Theory And Practice (1 st edition) (Unit I, II, III, IV)	Neal C Stoskopf, Dwight T Tomes, B. R. Christie, Bertram R Christie	CRC Press (ISBN 9780367298470)
Recent research papers and reviews		

Suggested Readings

Principles of Crop Improvement (2 nd edition) (Unit II)	Norman Simmonds, J. Smartt	Wiley-Blackwell
Genome Mapping in Plants (Unit IV)	Andrew H. Paterson	Academic Press
Principles of Plant Genetics and Breeding (Unit I, II)	George Acquaah	John Wiley & Sons, Ltd.
Marker-Assisted Plant Breeding: Principles and Practices (Unit II)	BD Singh, AK Singh	Springer

SEMESTER 3;S1

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-305

Human Genetics and Genomic Technologies

Course Objective: *This course provides an advanced understanding of human genetics, integrating classical and complex inheritance patterns, pedigree analysis, modern genomic sequencing technologies, genome editing systems (including CRISPR-Cas platforms), and ethical, legal, and social implications (ELSI) in prenatal, clinical, and population contexts.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-305 Human Genetics and Genomic Technologies	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Foundations of human inheritance and pedigrees	10
II	Genetic mechanisms beyond simple Mendelism	10
III	Human genomics and sequencing technologies	10
IV	Genome editing and ethical, legal, and social issues (ELSI)	15
Tutorial		
Various modalities as given below		15

Course outcome : On completing 'Human Genetics and Genomic Technologies, the students would have:

- A clear understanding of how classical experiments and human pedigrees reveal chromosomal, molecular, and complex patterns of inheritance, including examples relevant to the Indian population.
- Working knowledge of human genomics, including major DNA sequencing platforms and basic interpretation of sequence quality metrics and variant types in health and disease.
- The ability to compare and apply genome editing tools such as ZFNs, TALENs, and CRISPR systems to modify specific loci in the human genome.
- An integrated understanding of how large-scale genomics projects and genome editing outcomes inform our view of human genetic variation and complex disease.
- Practical skills in evaluating ethical, legal, and social implications of human genomics and genome editing, and in articulating balanced, policy-aware recommendations for their responsible use.

Content (Theory)**45 hours**

- I. **Foundations of human inheritance and pedigrees** (10 hours)
 - Historical foundations: Mendel's laws; Sutton-Boveri chromosomal theory; T.H. Morgan linkage/recombination; DNA as genetic material (Griffith, Avery-MacLeod-McCarty, Hershey-Chase)
 - Pedigree analysis: Standard symbols; constructing/interpreting pedigrees
 - Inheritance patterns: Autosomal dominant/recessive (features, examples including Indian contexts);
 - X-linked recessive/dominant (hemophilia, color blindness); Y-linked; mitochondrial (maternal transmission, heteroplasmy, threshold effects)
- II. **Genetic mechanisms beyond simple Mendelism** (10 hours)
 - Extensions: Incomplete dominance, codominance (e.g., blood groups); complementation; germline mosaicism
 - Penetrance/expressivity: Reduced/age-dependent penetrance; variable expressivity (neurofibromatosis); anticipation (repeat expansions)
 - Advanced mechanisms: Pleiotropy, locus/allelic heterogeneity; genomic imprinting (methylation, control regions);
 - Prader-Willi/Angelman syndromes (deletion/UPD/imprinting defects); epistasis; haploinsufficiency; dominant-negative mutations; synthetic lethality
 - loss of heterozygosity; genetic redundancy; catastrophic rearrangements (chromothripsis, chromoplexy)
- III. **Human genomics and sequencing technologies** (10 hours)
 - Sanger sequencing: Chain-termination, Phred scores, quality assessment
 - Illumina SBS: Library prep, bridge amplification, reversible terminators; 4/2/1 channel chemistries; read-length limits/signal decay; platforms (MiSeq vs NovaSeq)
 - Long-read technologies: Oxford Nanopore (ionic current, error patterns); PacBio/SMRT; applications (SV detection, phasing, isoforms); MinION vs PromethION
 - Emerging: Aviti/polony chemistries; library strategies (TruSeq/Trinity-class, indexing)
 - Human Genome Project: Goals, milestones; post-HGP (variation landscape: SNPs/indels/CNVs); GWAS (common disease-common variant, polygenic scores, limitations); cancer genomics implications
- IV. **Genome editing and ethical, legal, and social issues (ELSI)** (15 hours)
 - Editing platforms: ZFNs/TALENs (architecture, challenges); CRISPR-Cas9 (gRNA, PAM, NHEJ/HDR); base/prime editing; PCSK9 therapeutic example
 - CRISPR biology: crRNA/tracrRNA/spacer/Cas1-2 acquisition; advanced (pegRNA/nickase/RT in prime editing)
 - RNA-targeting: Cas13 advantages (reversibility); collateral cleavage; diagnostics (Sherlock/Cas12-13); dCas13-ADAR fusions (REPAIRv2, specificity)
 - ELSI: Principles (autonomy, beneficence, etc.); confidentiality/privacy; prenatal/reproductive issues; predictive testing/minors; incidental findings; thalassemia screening; surrogacy; cloning (reproductive/therapeutic); eugenics; organ banking; AI risk scores bias

Content (Tutorials)**15 hours****Addressing individual queries on class concepts**

- Clarification of challenging lecture concepts (e.g., locus heterogeneity vs allelic heterogeneity, chromothripsis, read-length constraints, prime editing logic)
- Pedigree problem sets covering multiple inheritance modes, penetrance/expressivity, and risk calculations
- Short technology critiques: Comparing MiSeq vs NovaSeq, MinION vs PromethION, and short-read vs long-read applications · Evaluating sequencing quality using Phred scores
- and simple QC outputs
- Guided reading and discussion of landmark papers and case reports on HGP, GWAS, CRISPR genome editing, imprinting disorders, mitochondrial inheritance, and
- catastrophic genome rearrangements
- Structured ELSI case discussions (small groups) on prenatal diagnosis, predictive testing in minors, incidental findings, cloning, surrogacy, and eugenics
- Written and oral presentations on assignment prompts (therapeutic cloning, soft eugenics, AI-based risk scores)

Discussions on relevant academic resources, videos/ TED talks

- Discussions on landmark discoveries and milestones in human genetics and genomics
<https://www.youtube.com/watch?v=cR5An16ifjQ>
- The Human Genome Project: A Decade Later | Francis Collins |
<https://www.youtube.com/watch?v=Gnt2SJkt83Q>
- CRISPR: Gene editing and beyond | Jennifer Doudna | TED
<https://www.youtube.com/watch?v=TdBAHexVYzc>
- The ethical dilemma of designer babies | Paul Knoepfler | TED
<https://www.youtube.com/watch?v=nOHbn8Q1fBM>
- Ethical dimensions of CRISPR and human genome editing | Various panel discussions
https://www.youtube.com/watch?v=LmMuTCn-N_M
- Sequencing the human genome:
<https://www.youtube.com/watch?v=aRWWldz2YZc>

Key Papers:

- International HapMap Consortium (2005), "A haplotype map of the human genome", Nature 437, 1299–1320: doi:10.1038/nature04226
- 1000 Genomes Project Consortium (2015), "A global reference for human genetic variation", Nature 526, 68–74: doi:10.1038/nature15393
- Lek et al. (2016), Exome Aggregation Consortium (ExAC), "Analysis of protein-coding genetic variation in 60,706 humans", Nature 536, 285–291: doi:10.1038/nature19057
- Karczewski et al. (2020), gnomAD, "The mutational constraint spectrum quantified from variation in 141,456 humans", Nature 581, 434–443: doi:10.1038/s41586-020-2308-7

Essential Reading

1.	Human Molecular Genetics (Unit I, II, III)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II, III, IV)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Reading

1.	Principles of Population Genetics (Unit I, II)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit I, II)	Gillespie JH	Johns Hopkins University Press
3.	Human Evolutionary Genetics (Unit II)	Jobling MA et al.	Garland Science
4.	An Introduction to Population Genetics (Unit I, II, III)	Nielsen R & Slatkin M	Sinauer Associates

SEMESTER 3;S2

GENERAL ELECTIVE

2Y-PG

GE-GEN-310

Genetics in Human Health

Course Objective: This elective paper has been designed to introduce students from other departments to the basic concepts in genetics, with a specific focus on human health. It also aims to provide an overview of the classical and contemporary genetic tools for the improvement of overall life quality. The various aspects of medical genomics focus on tools for genetic analysis of human disorders, the translation of findings for predictive, preventive, personalized, and participatory (P4) medicine, and cellular and animal models of disease for enhanced understanding of disease biology and the development of new therapeutics.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-GEN-310 Genetics in Human Health	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Characteristics of the human genome	3
II	Analysis of genetic disorders	21
III	Clinical cytogenetics and molecular diagnostics	14
IV	Modelling of human genetic disorders and intervention strategies	7
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Genetics in Human Health', the students would have:

- A clear understanding of human gene, genome, and chromosome structure, the principles of Mendelian and non-Mendelian inheritance, and the nature of genetic variation in human populations.
- Working knowledge of the molecular basis of human disease, including how different classes of mutation, genotype–phenotype correlations, and gene–environment and epigenetic interactions contribute to rare, common, and cancer-associated disorders.
- The ability to explain and apply major genomic technologies and diagnostic tests, interpret results for clinical use, and recognize key ethical, legal, and social dimensions of genetic testing, counselling, and personalized medicine.
- An integrated understanding of how diverse model organisms are used to mimic human disease mutations, explore conserved gene functions, and perform genetic or drug modifier screens using advanced genetic and genome editing tools.

Content (Theory)

45 hours

I. Characteristics of the human genome (3 hours)

- Introduction of human chromosomes, genes, and genomes.
- An overview of the genetic and molecular basis of syndromes and disorders

II. Analysis of genetic disorders (21 hours)

- Pedigrees: Symbols, construction of pedigrees,
- Inheritance patterns: Dominant, recessive, sex-linked and sex-limited patterns, mitochondrial inheritance.
- Complications to the basic pedigree patterns: Non-penetrance, variable expressivity, late-onset, genomic imprinting, mosaicism and chimerism, X-inactivation, risk assessment.
- Monogenic diseases with established molecular pathology: Cystic fibrosis, Tay-Sachs syndrome
- Polygenic and complex traits/ disorders: Polygenic inheritance, 'Nature -nurture' concept, monozygotic and dizygotic twins. Atherosclerosis, diabetes mellitus
- Genome imprinting syndromes: Prader-Willi and Angelman syndromes
- Repeat expansion disorders/ syndrome: Huntington's disease and fragile X-syndrome
- Genomic instability and cancer: Cell cycle checkpoint and cancer, oncogenes, tumour suppressor genes, DNA repair genes, and genetic instability
- Inborn errors of metabolism and their genetic basis: Phenylketonuria, maple syrup urine syndrome

III. Clinical cytogenetics and molecular diagnostic (14 hours)

- Cytogenetic and molecular diagnostics: Overview of prenatal, neonatal, and adult diagnosis strategies
- Human metaphase chromosomes: types and characteristics
- Human karyotype: banding types, pathology of human chromosomes, common syndromes due to numerical and structural alterations

IV. Modelling of human genetic disorders and intervention strategies (7 hours)

- Modelling of human genetic disorders/ diseases (such as cancer, neurodegenerative disorders) in *Drosophila*, zebrafish, and mouse.
- Screening of genetic modifiers, drug targets, and drugs.
- Management of genetic disorders: Genetic counselling, gene therapies, ethical, legal, and social issues

Content (Tutorial)

15 hours

- Addressing individual queries on class concepts
- Discussing research/ review papers on seminal work in the field of human genetics and medical genetics
- Duong D, Solomon BD. (2025) Artificial intelligence in clinical genetics. *Eur J Hum Genet.* 33(3):281-288. DOI: 10.1038/s41431-024-01782-w
- The Cell Editorial Team. Five decades of genetics and genomics. *Cell.* DOI: 10.1016/j.cell.2024.01.020
- Lamm, Ehud et al. "Before Watson and Crick in 1953 Came Friedrich Miescher in 1869." *Genetics.* 2020;215(2):291-296. DOI: 10.1534/genetics.120.303195
- Mayor, S. "First human chromosome is sequenced." *BMJ.* 1999;319(7223):1453a. DOI: 10.1136/bmj.319.7223.1453a

- Ponting CP. Human genetics seen through an evolutionary lens. *Cell Genom.* 2023;3(5):100323. DOI: 10.1016/j.xgen.2023.100323
- Drets ME, Shaw MW. (1971) Specific banding patterns of human chromosomes. *Proc Natl Acad Sci U S A.* 68(9):2073-2077. DOI: 10.1073/pnas.68.9.2073
- Cohen JS et al. (2022) Genomic answers for children: Dynamic analyses of >1000 pediatric rare disease genomes. *Genet Med.* 24(6):1336-1348. DOI: 10.1016/j.gim.2022.02.007
- Roth TL, Marson A. (2021) Genetic Disease and Therapy. *Annu Rev Pathol.* 16:145-166. DOI: 10.1146/annurev-pathmechdis-012419-032626
- Science Editorial – Modeling Human Disease. *Science.* DOI: 10.1126/science.1227179
- Discussions on relevant TED talks/ academic videos/ digital resources
 - Can we cure genetic diseases by rewriting DNA? By David R. Liu
<https://www.youtube.com/watch?v=ONs9FCY74p0>
 - The human journey-- a genetic odyssey: Spencer Wells at TEDxConnecticutCollege
<https://www.youtube.com/watch?v=xnbxrDGZoBQ>
 - How genetics and environment work together to shape our destiny: Milena Georgieva at TEDxAUBG <https://www.youtube.com/watch?v=gfDikwoAbPk>
 - The World's Rarest Diseases — And How They Impact Everyone | Anna Greka | TED
<https://www.youtube.com/watch?v=n0J1zCHURsQ>
 - The Power of a Genetic Diagnosis | Dr. Vincent Carson | TEDxLancaster
https://www.youtube.com/watch?v=CZ4O_h1wYoo
 - What Is Genetic Counseling? | Jaclyn Haven | TEDxHelena
<https://www.youtube.com/watch?v=7yIW0L9dLCQ>
 - The age of genetic wonder | Juan Enriquez | TEDxCERN
<https://www.youtube.com/watch?v=GPIVILKI5LE>

Essential Readings

1.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Readings

1.	iGenetics A Molecular Approach (Unit I, II)	Russell PJ	Pearson
2.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
3.	Human Genetics (Unit I, II, III)	Ricki Lewis	McGraw Hill
4.	Medical Genetics (Unit III, IV)	Jorde et al.	Elsevier
5.	Genetics and Genomics in Medicine (Unit III, IV)	Cohn et al.	Elsevier
6.	New Clinical Genetics (Unit I, III, IV)	Andrew Read and Dian Donnai	Scion Pub Ltd
7.	Emery's elements of medical genetics and genomics (Unit I, III, IV)	Peter Turnpenny	Elsevier
8.	Evolution of Medical Genetics (Unit II, III)	Peter Harper	CRC Press
9.	Relevant Review and Research Papers (Unit I, II, III, IV)		

SEMESTER 3; S1

SKILL BASED COURSE

2Y-PG

SBC-GEN-311

Advanced Research Methodology

Course Objective: This course comes under the course type Skill-based course/ workshop/ Specialised laboratory/ Internship/ Hands on Learning. This course teaches essential steps of research in life sciences, from formulating questions to presenting findings. Conceptual teaching and hands-on activity based practical will be employed.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-311 Advanced Research Methodology	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		Teaching
I	Framing research questions	8
II	Data collection and analysis	7
Practical		
I	Analysing given sets of data and identifying problems within the data, if any	15
2	Research paper presentation	15

Course Learning Outcome: On completion of 'Research Methodology' students would have:

- Developed the ability to distinguish and choose between various study designs as suited for different studies
- Understood various sampling methods and their applications
- Demonstrated critical thinking and data analysis skills

Content (Theory)**15 hours****I. Framing Research Questions**

- Definition and purpose of scientific research
- Historical contributions of research in life sciences
- Difference between basic and applied research
- Ethics in life sciences research (human/animal subjects, environmental impact)
- Overview of the scientific method
- Identifying a research problem
- Literature review: finding and evaluating relevant studies
- Formulating hypotheses and objectives
- Experimental vs. bioinformatics approaches
- Characteristics of a good research question (specific, measurable, achievable, relevant, time-bound)
- Practical Activity: Hands-on literature review using PubMed/Google Scholar
- Types of research design: Experimental, observational, descriptive, correlational
- Study designs in life sciences: Cross-sectional, longitudinal, case-control, cohort studies
- Importance of sampling
- Types of variables
- Experimental and control groups
- Importance of removing bias and selecting controls in research
- Pilot studies and feasibility analysis
- Testing and validation

II. Data Collection and Analysis

- Primary vs. Secondary Data
- Data collection techniques
- Laboratory experiments
- Field studies, surveys, Interviews and questionnaires
- Follow standardized procedures for reproducibility
- Standard methods of recording data
- Use of databases and bioinformatics tools
- Data integrity and quality control

Content (Practical)**30 hours**

Unit I: Analysing given sets of data and identifying problems within the data, if any

Unit II: Task based exercises on study design and analyzing given research papers

Essential Reading

- | | | | |
|----|---|---------------------------|-------------------------|
| 1. | A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods (Unit I, II) | Mukherjee , Shyama Prasad | Taylor and Francis 2020 |
| 2. | Research Methodology: The Aims, Practices and Ethics in Science (Unit I, II) | Peter Pruzan | Springer 2016 |

Suggested Reading

Various research papers as suggested by the teacher in classroom (Unit I, II)

SEMESTER 4 (2Y-PG) Structure 1-Coursework

Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	2	3 (3DSE+0GE; 2DSE+1GE)	1	0	6
Credits	8	12	2	0	22
Student needs to complete 8+12+2+0 = 22 credits					

Course Distribution and Overview

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSC-GEN-401	DSC	Population and Quantitative Genetics	4	3	1	0
DSC-GEN-402	DSC	Application of Genetic Studies in Clinical Research and Plant Biotechnology	4	3	1	0
DSE-GEN-403	DSE	Advances in Drosophila Genetics	4	3	0	1
DSE-GEN-404	DSE	Biology of Dictyostellium	4	3	0	1
DSE-GEN-405	DSE	Cancer Biology and Genetics	4	3	0	1
DSE-GEN-406	DSE	Molecular Plant -Microbe Interaction	4	3	0	1
DSE-GEN-407	DSE	Yeast Genetics	4	3	0	1
GE-GEN-410	GE	Basic Science to Biological Applications	4	3	0	1
SBC-GEN-411	SBC	Scientific Writing and Presentation	2	1	1	0

1 credit = 15 hours of teaching/ 30 hours of practical/ 15 hours of tutorials

SEMESTER 3; S1

DISCIPLINE SPECIFIC CORE

2Y-PG

DSC-GEN-401

Population and Quantitative Genetics

Course Objective: *This course introduces the theoretical foundations of population genetics, integrating classical models with modern genomic data on human variation. It covers genetic variation, evolutionary forces, Hardy-Weinberg principles, linkage disequilibrium, population structure, human evolutionary and demographic history, and the use of large reference datasets (HapMap, 1000 Genomes, ExAC, gnomAD, Ensembl) for variant interpretation and inference in human genetics.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-401 Population and Quantitative Genetics	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Genetic variation, mutation, and basic population-genetic quantities	10
II	Hardy–Weinberg equilibrium, evolutionary forces, and analytical problems	10
III	Evolutionary genetics, population structure, and human demographic history	10
IV	Human reference panels, databases, and applications in human genetics	15
Practical		
	Modelling Mendelian inheritance	15
	Genotyping polymorphisms in human genes using PCR and RFLP	15

Course outcomes : On completing ‘Population and Quantitative Genetics’, the students would have:

- Analyze how evolutionary theory and Mendelian genetics give rise to population-level concepts such as gene pools and allele and genotype frequencies.
- Apply the Hardy–Weinberg principle to predict genotype frequencies from allele frequencies and to assess departures from equilibrium in real datasets.
- Adopt a research mindset to evaluate how key evolutionary forces (mutation, selection, drift, migration, recombination) shape levels and patterns of human genetic diversity.
- Visualize genomic datasets by retrieving and exploring gene and variant information from genome browsers and population genetics databases.
- Use large reference panel datasets to support variant interpretation and to investigate the genetic basis of disease, demography, and human population history.

Content (Theory)**45 hours**

- I. Genetic variation, mutation, and basic population-genetic quantities (10 hours)**
- Historical foundations: Darwinian evolution and Mendelian inheritance; modern synthesis (Fisher); population definition, gene pool, allele/genotype frequencies
 - Types of genetic variation: SNPs, indels, STRs/microsatellites, CNVs, structural variants
 - Allele terminology: reference/alternate, major/minor, risk/protective, ancestral/derived
 - Mutation mechanisms: DNA replication errors, proofreading; per-base/per-division/per-generation rates; mutation load per zygote; higher rates at CpG sites
- II. Hardy–Weinberg equilibrium, evolutionary forces, and analytical problems (10 hours)**
- Allele frequency vs effect size; haplotypes, phasing (statistical/family-based); measuring variation (arrays vs sequencing, tag SNPs, imputation)
 - Linkage disequilibrium (LD): Definitions (D , r^2); factors (distance, recombination hotspots/PRDM9, drift, selection, demography); examples (extended LD in Tibetan high-altitude adaptation, HIF pathway)
 - Hardy–Weinberg principle: Assumptions, derivation (bi-allelic/multiple alleles); genotype from allele frequencies
 - Evolutionary forces: Mutation (forward/back, mutation-selection balance); migration/gene flow (island model); non-random mating (inbreeding, assortative); drift (effective population size, founder/ bottleneck); selection (fitness, coefficients, over/underdominance)
 - Quantitative problems: Allele/ genotype frequency calculations; recessive trait/carrier estimates; HWE testing (chi-square); selection modeling across generations
- III. Evolutionary genetics, population structure, and human demographic history (10 hours)**
- Forces shaping diversity: Mutation, drift, selection, migration, recombination; paternal age effect on de novo mutations; mutation-drift balance
 - Diversity comparisons: Great apes vs humans; effective population size; allele frequency spectra, segregating sites, rare/common variants
 - Population differentiation: F_{st} (definition, values); population-specific rare variants; genetic distance (D_{ij})
 - Structure analysis: PCA (dimension reduction, genotype matrices, plots interpretation, clines/clusters); relation to F_{st}
 - Human history: Out-of-Africa model, continental splits, admixture; case studies (Ashkenazi Jewish bottlenecks/founder events)
 - Race vs ancestry: Biological imprecision of race; variation mostly within groups; limited predictive power for individual genotypes/traits (polygenic scores limitations)
- IV. Human reference panels, databases, and applications in human genetics (15 hours)**

- Ensembl: Genome browser/annotation; gene/transcript counts, regulatory features, variant catalogs, allele frequencies, functional annotations
- HapMap: Aims (haplotype map, tag SNPs); populations; role in GWAS
- 1000 Genomes: Rationale (rare variants, diverse populations); phases (low-coverage/exome/high-coverage); findings (rare variants abundance, structure, structural variants); implications for disease/demography
- ExAC: Exome aggregation; constraint metrics; distinguishing pathogenic/benign variants
- gnomAD: Expansion (exomes + genomes, larger/diverse samples); comparison with ExAC/HapMap/1000 Genomes
- Applications: Rare functional variants in exomes; variant interpretation in clinical/research; medical genetics uses

Content (Practical)

30 hours

I. Modeling Mendelian inheritance.

Objective: To model the inheritance of a simple recessive trait in a population (individuals within class) across five generations. This will help students observe genotype and phenotype frequencies and how small population size affects inheritance patterns due to random factors.

II. Genotyping polymorphisms in human genes using PCR and RFLP.

Objective: To genotype SNP (single nucleotide polymorphisms) in genes with known health implications, such as CYP450 (associated with drug metabolism) and MTHFR (associated with folate metabolism). By genotyping these SNPs, students may investigate the genetic basis of variability in drug response or nutrient processing and relate these to potential health outcomes.

Essential Reading

1.	Principles of Population Genetics (Unit I, II, III, IV)	Hartl DL & Clark AG	Sinauer Associates
2.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science

Suggested Reading

1.	Principles of Population Genetics (Unit I, II, III, IV)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit I, II)	Gillespie JH	Johns Hopkins University Press
3.	Genetics: A Conceptual Approach (Unit I)	Pierce BA	W.H. Freeman
4.	Human Evolutionary Genetics (Unit II, III)	Jobling MA et al.	Garland Science
5.	An Introduction to Population Genetics (Unit I, II, III)	Nielsen R & Slatkin M	Sinauer Associates
6.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science

DSC-GEN- 402

Application of genetic studies in clinical research and plant biotechnology

Course Objective: This course delves into the significance of genetic studies in plant biotechnology and clinical research, highlighting their applications in disease diagnosis, crop security, personalized medicine, and gene therapy. It provides an in-depth understanding of various genetic technologies used in healthcare and crop improvement, along with the ethical aspects surrounding their use. Emphasis is placed on how these advancements translate into real-world applications.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-402 Application of genetic studies in clinical research and plant biotechnology	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Applications of Plant Cell and Tissue Culture Technology	11
II	Applications of plant transgenic technology	11
III	Introduction to clinical genetics and genomic medicine	11
IV	Gene therapy and Genome editing in clinical research	12
Practical		
I	Plant tissue culture; regeneration techniques; Agrobacterium mediated genetic transformation of plants.	15
II	Experiments on cfDNA isolation and analysis	15

Course outcomes : On completing 'Application of genetic studies in clinical research and plant biotechnology', the students would have:

- A clear understanding of how plant cell and tissue culture are applied for crop improvement, germplasm preservation, and production of high-value metabolites.
- Working knowledge of plant transgenic technologies for enhancing biotic and abiotic stress resistance, modifying developmental and quality traits, and producing high-value biomolecules, with awareness of public concerns surrounding GM crops.
- The ability to explain core concepts of clinical genetics and genomic medicine, including how human genetic variation underpins disease risk, diagnosis, and prognosis, and how genomic data inform personalized therapies.
- An integrated understanding of gene therapy and genome editing approaches in clinical and agricultural settings, including their mechanisms, therapeutic potential, limitations, and the ethical, legal, and social issues they raise.
- Practical skills in applying genetic and genomic techniques to real-world problems in health and agriculture, interpreting experimental or case-based data, and formulating responsible, evidence-based recommendations for their use in clinical research and plant biotechnology.

Content (Theory)**45 hours****I. Applications of Plant Cell and Tissue Culture**

- Technology- Micropropagation, Virus-free plants, Artificial seeds
- Embryo rescue and in vitro fertilization for hybrid development
- Breakage of seed dormancy
- Haploids, double haploids and triploids
- Somatic hybrids, cybrids and asymmetric hybrids
- In vitro mutants and somaclones for crop improvement
- Production of secondary metabolites; In vitro gene banks and germplasm conservation
- Other applications

II. Applications of plant transgenic technology

- Scope
- Insect resistance - case study of Bt cotton, Bt and other anti-feedant genes
- Resistance management
- Herbicide resistance - study of glyphosate resistance
- Transgenic resistance against viral, bacterial, fungal pathogens and nematode parasites
- Abiotic stress tolerance
- Engineering crops for male sterility, delayed fruit ripening and fatty acid composition
- Nutritional quality and quantity improvement, Metabolic engineering - Golden rice, Hairy roots and secondary products
- Molecular pharming - Production of antibodies, edible vaccines, recombinant proteins, bioplastics, biosteel and other products, Transgenics for cleaning environmental pollutants and production of bio-fuels
- RNAi applications in agriculture
- Other applications
- Global status of GM crops
- Regulations and issues in bio-safety of commercialization and consumption of GM plants and foods.

III. Introduction to clinical genetics and genomic medicine

- Principles of human inheritance, pedigree analysis and genetic risk calculation.
- Chromosomal and single-gene disorders; cytogenetic and molecular diagnostic techniques.
- Genomic technologies in medicine (gene panels, exome/genome sequencing) and variant interpretation.
- Applications in cancer genomics.
- Ethical, legal and social issues; organization of clinical genetic and counseling services.

IV. Gene therapy and Genome editing in clinical research

- Concepts and historical development of human gene therapy; somatic vs germline and in vivo vs ex vivo approaches.
- Gene transfer vectors and delivery systems: viral (AAV, lentiviral, retroviral, adenoviral) and non-viral.
- Genome editing platforms (ZFNs, TALENs, CRISPR-Cas) and design of editing strategies.
- Preclinical models, major clinical applications and selected case studies (e.g. hemoglobinopathies, retinal disease, CAR-T).
- Safety, regulatory and ethical issues in gene therapy and human genome editing; future directions (base/prime editing, epigenome editing).

Content (Practical)**30 hours****I. Experiments on plant transformation**

- i. Shoot tip and nodal bud culture for multiplication
- ii. Plant regeneration (organogenesis)

- iii. Induction of embryogenic callus and plant regeneration in rice
- iv. Agrobacterium-mediated genetic plant transformation

II. Experiments on cfDNA isolation and analysis

- i. Culture of mammalian cell lines and collection of conditioned media for cfDNA.
- ii. Isolation and precipitation of cfDNA from cell culture supernatant.
- iii. Quantification of cfDNA using Qubit dsDNA High Sensitivity assay.
- iv. Fragment length analysis of cfDNA using TapeStation and interpretation of profiles.

Essential Reading

1.	Plant Cell and Tissue Culture (Unit I, II)	Vasil IK & Thorpe TA	Springer
2.	Biotechnology and Crop Improvement Tissue Culture and Transgenic Approaches (Unit I, II)	Nitish Kumar	Taylor & Francis Group
3.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science
4.	Recent Reviews and research paper (Unit I, II, III, IV)		

Suggested Reading

1.	Principles of Population Genetics (Unit II, III)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit II, III)	Gillespie JH	Johns Hopkins University Press
3.	Genetics: A Conceptual Approach (Unit II, III)	Pierce BA	W.H. Freeman
4.	Human Evolutionary Genetics (Unit II, III)	Jobling MA et al.	Garland Science
5.	An Introduction to Population Genetics (Unit II, III)	Nielsen R & Slatkin M	Sinauer Associates
6.	Human Molecular Genetics (Unit II, III)	Strachan T & Read A	Garland Science
7.	Three strategies of transgenic manipulation for crop improvement (Unit I, II)	Yu H, Yang Q, Fu F, Li W	Front Plant Sci. 13:948518
8.	Applications of Plant Cell and Tissue Culture (Unit I, II)	Bock GR & Marsh J	Wiley

SEMESTER 4; S1

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN- 403

Advances in *Drosophila* Genetics

Course Objective: This specialized paper has been designed to provide an advanced understanding of contemporary *Drosophila* genetics and related areas. *Drosophila* has been one of the favored model organisms of geneticists since T. H. Morgan decided to use it in 1910 to investigate the chromosomal theory of inheritance. Thereafter, succeeding generations of “*Drosophilists*” have developed an ever-increasing repertoire of techniques that make *Drosophila* as an indispensable and one of the most tractable multicellular organisms for biomedical research.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-403 Advances in <i>Drosophila</i> Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	<i>Drosophila</i> : An indispensable organism for biomedical research	6
II	Molecular genetics of <i>Drosophila</i> gametogenesis and development	20
III	<i>Drosophila</i> -specific genetic toolkits for functional analysis of genes	10
IV	<i>Drosophila</i> as a model for human genetic disorders, drug screening, aging, and behavioral studies	9
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing ‘Advances in *Drosophila* Genetics’, the students would have:

- Developed a comprehensive understanding of the historical, genetic, and biomedical significance of *Drosophila melanogaster*
- Acquired an integrated understanding of molecular genetic mechanisms underlying development and regulatory processes across life stages.
- Developed the ability to use genetic and molecular approaches to interpret spatial and temporal control of genes.
- Expanded their proficiency in applying advanced genetic tools and genome engineering strategies.
- Understood the capacity of *Drosophila* to model human genetic diseases for therapeutic implications.

Content (Theory)**45 hours**

- I. *Drosophila*: An indispensable organism for biomedical research** 6 hours
- An Introduction- Historical perspective, an overview of the life cycle and advantages in genetic analysis, developmental studies, and biomedical research, the nomenclature of genes and mutations, balancer and marker chromosomes and associated common phenotypes, strategies to design genetic crosses, and an overview of *Drosophila*-specific online databases, stock centers, and other resources.
- II. Molecular genetics of *Drosophila* gametogenesis and development** 20 hours
- Axis specification and cellular signalling during oogenesis- *Drosophila* female reproductive system, an overview of the oogenesis and stage identification, selection of potential oocyte, somatic and germ cell derivatives
 - Delta, JAK/STAT, Notch signalling and specification of A/P polar cells and axis determination, ring canals, transportation and localization of transcripts and protein in the oocyte, Gurken signalling and axis determination, border cell migration, cytoplasmic dumping, and oocyte maturation. Analysis of some female sterile mutant lines.
 - Cellular remodelling and differentiation during spermatogenesis-*Drosophila* male reproductive system, mitotic and meiotic cell divisions, spermatogonia, spermatocytes, cyst cell, mitochondrial remodelling, nebenkern, nuclear shaping, actin polymerization, sperm individualization.
 - Overview of embryogenesis, axis formation, and fate map.
 - Genetic hierarchy of development in *Drosophila*- egg polarity genes, the establishment of morphogen gradient, gap genes, pair-rule genes, specification of stripes, regulation of pair-rule gene expression, segment polarity genes, the establishment of segment polarity, homeotic genes, and mutations, antennapedia/bithorax complex, and specification of body organs
 - Larval stages and tissue types, imaginal discs - development and differentiation, axis determination in imaginal discs, regeneration and trans-differentiation, adult morphology, and internal organs
- III. *Drosophila*-specific genetic toolkits for functional analysis of genes** 10 hours
- Genetic tools- Genetic tools for studies on gene expression
 - Generation and analysis of FLP/FRT-mediated somatic clones. MARCM (Mosaic analysis with a repressible cell marker), Generation and analysis of ovoD-mediated germ-line clones
 - Conditional and/or targeted over-expression/ablation of genes/transcripts (e.g. UAS/GAL4/GAL80 system)
 - RNAi-based screening of gene functions, *Drosophila* genome editing by CRISPR-Cas9
 - Stem cells and their maintenance- Somatic and germline stem cells
 - Components and functions of stem cell niches
 - Stemness, Various cellular signalling (i.e. Delta-Notch, JAK-STAT etc.), and maintenance of stemness
 - Differentiation of stem cells and maintenance of organ homeostasis
 - Therapeutic usages of stem cells
 - *Drosophila*- a model system to study immune responses, Induction of immune response, antimicrobial defence, Toll, and Immunodeficiency (IMD) signalling pathways.

IV. *Drosophila* as a model for human genetic disorders, drug screening, aging, and behavioral studies

9 hours

- Modeling of neurodegenerative disorders (i.e. Parkinson's, Huntington's, Alzheimer's diseases etc.), fragile-X syndrome, cancer, mitochondrial dysfunction, cardiac and muscular diseases etc
- Screening and identification of modifier genes, drug targets, and drug molecules
- *Drosophila* in drug screening and toxicological studies, Circadian rhythm in *Drosophila*
- Usages of *Drosophila* in behavioral genetics and aging research

Content (Tutorial)

15 hours

- **Addressing individual queries on class concepts**
- **Discussing research papers on seminal work in the field, exemplified by the following**
 - Morgan TH. (1910) Sex limited inheritance in *Drosophila*. *Science*. 1910 Jul 22;32(812):120-2. <https://www.science.org/doi/10.1126/science.32.812.120>
 - Lewis EB. (1978) A gene complex controlling segmentation in *Drosophila*. *Nature*. 276(5688):565-70. <https://www.nature.com/articles/276565a0>
 - Konopka RJ, Benzer S. (1971) Clock mutants of *Drosophila melanogaster*. *Proc Natl Acad Sci U S A*. 68(9):2112-6.
 - Victor Atoki et al., (2025) Exploring the versatility of *Drosophila melanogaster* as a model organism in biomedical research: a comprehensive review. *Fly (Austin)*. 19(1):2420453. <https://doi.org/10.1080/19336934.2024.2420453>
 - Brumby AM, Richardson HE. (2005) Using *Drosophila melanogaster* to map human cancer pathways. *Nat Rev Cancer*. 5(8):626-639. <https://www.nature.com/articles/nrc1671>
 - Kimble J, Nüsslein-Volhard C. (2022) The great small organisms of developmental genetics: *Caenorhabditis elegans* and *Drosophila melanogaster*. *Dev Biol*. 485:93-122. <https://doi.org/10.1016/j.ydbio.2022.02.013>
 - Suzuki, DT. (1970) Temperature-sensitive mutations in *Drosophila melanogaster*. *Science*, 170:695-706. <https://www.science.org/doi/10.1126/science.170.3959.695>
 - Hales KG, Korey CA, Larracuenta AM, Roberts DM. (2015) Genetics on the fly: A primer on the *Drosophila* model system. *Genetics*. 201:815 <https://doi.org/10.1534/genetics.115.183392>
 - Bellen HJ, Tong C, Tsuda H. (2010) 100 years of *Drosophila* research and its impact on vertebrate neuroscience: a history lesson for the future. *Nat Rev Neurosci*. 11:514-22. <https://www.nature.com/articles/nrn2839>
- **Discussions on relevant academic resources, videos/ TED talks**
 - Discussions on Nobel Prize-winning discoveries using *Drosophila* as a model organism.
 - The why of the fly | Daniel N. Cox | TEDxGeorgeMasonU <https://www.youtube.com/watch?v=UMeS1gBdzgk>
 - Eric Wieschaus (Princeton) Part 1: Patterning Development in the Embryo <https://www.youtube.com/watch?v=Ncxs21KEj0g>
 - Eric Wieschaus (Princeton) Part 2: Stability of Morphogen Gradients & Movement of Molecules <https://www.youtube.com/watch?v=cpOf5el9Gik>
 - The Fruit Fly as Human Disease Research Tool, Harvard University Educational Video <https://www.youtube.com/watch?v=0cte6rowhao>

- *Drosophila* circadian rhythms, memory and disease models. Faculty of Life Sciences, University of Bristol. <https://www.youtube.com/watch?v=MoS-9Hgzcro>
- Drugs, dopamine and *Drosophila* - A fly model for ADHD? | David Anderson | TEDxCaltech https://www.youtube.com/watch?v=L8Bd_p8pbQI
- Eric Wieschaus and Christiane Nüsslein-Volhard: Collaborating to Find Developmental Genes <https://www.youtube.com/watch?v=GmQ9eI1vdGM>

Essential Reading

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
<i>Drosophila</i> Guide (Unit I)	Demerec & Kaufmann	Carnegie Press
<i>D. melanogaster</i> : Practical Uses in Cell and Molecular Biology (Unit I, II, III, IV)	Goldstein & Fyrberg	Academic Press
The making of a fly: The genetics of animal design (Unit III, IV)	Lawerence	Blackwell
<i>Drosophila</i> : Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of <i>Drosophila</i> Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
<i>Drosophila</i> : A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

SEMESTER 4; S1

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN- 404

Biology of Dictyostelium

Course Objective: The course is designed to provide some fundamental principles to form an integrated view of various genetic and molecular processes using *Dictyostelium discoideum* as a model system. Tutorials would be in the form of discussions on research and review papers related to each topic, highlighting the advances made in the field.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Biology of Dictyostelium	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	hours
Theory		
I	Introduction to <i>Dictyostelium</i>	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	<i>Dictyostelium</i> in biology and medicine	3
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Biology of Dictyostelium', the students would have:

- Appreciated the classical experiments, emergence of *D. discoideum* as a model organism
- Acquired an in-depth understanding of structural, cellular, biological and regulatory mechanisms of *D. discoideum*
- Developed an understanding of how *D. discoideum* cells respond to nutrient cues using novel and conserved signaling pathways for development and features for cell differentiation.
- Ascertained the relevance of *D. discoideum* as a model system for human diseases

Content (Theory)**45 hours****I. Introduction to *Dictyostelium* (8 hours)**

- An overview; *Dictyostelium discoideum* and its relatives
- History of research on *D. discoideum*
- Classical experiments of Kenneth Raper; Chemotaxis and aggregation
- Evolution and Genome
- Life cycle
- Molecular techniques

II. Cellular organization and initiation of developmental process (9 hours)*Cellular organization and Dynamics*

- Plasma membrane, channels and pumps, macropinocytosis, phagocytosis; Lysosomes; The autophagic vacuoles; Cytoskeletal proteins; Cytokinesis; Cell motility

Initiation of Development

- Transition from growth to development, detection of starvation, events after starvation, Cellular and molecular mechanisms; Factors controlling early development; Sexual development, macrocyst formation

III. Developmental processes and signaling pathways (23 hours)*Chemotaxis and Aggregation*

- Components of cAMP signal transduction and relay pathway, Secondary messengers and cytoskeletal events; Role of PKA; Developmental regulation of chemotactic components; Role of cGMP and calcium in chemotaxis; Polarity of movement

Cell adhesion and Recognition

- Cell adhesion molecules, cell-cell contact and gene expression; Cell recognition in the sexual development

Signal transduction

- Diffusible molecules
- cAMP signaling, cAMP oscillation and signal relay
- control of aggregation, cell sorting, coordinated cell movement during multicellular morphogenesis
- Prespore gene expression
- Peptide signaling

Cell differentiation and Pattern formation

- Initial cell type choice, cell type specific markers, Cell fate determination
- DIF signaling, DIF-1 and prestalk gene expression
- Prestalk and stalk cell heterogeneity
- Calcium in pattern formation and various models for pattern formation
- Coordinated cell movement and Morphogenesis

IV. *Dictyostelium* in biology and medicine (3 hours)**Content (Tutorial)****15 hours**

- Addressing individual queries on class concepts

- Discussing research papers on seminal work in the field
- Images and videos for learning life cycle, cell differentiation, chemotaxis and other events during growth and developmental
 - A video on *Dictyostelium discoideum*- a slime mold) <https://www.youtube.com/watch?v=5h8WOWEqP6o>
 - John Bonner's slime mold videos <https://www.youtube.com/watch?v=bkVhLJLG7ug>
 - Coronin and phagocytosis <http://dictybase.org/Multimedia/phagocytosis/gerisch4.avi>
 - cell tracks and a moving slug http://dictybase.org/Multimedia/development/on_agar_cell_tracks.mov
 - Aggregation towards cAMP <http://dictybase.org/Multimedia/development/ax320x.mov>
 - Chemotaxis of large field of cells <http://dictybase.org/Multimedia/development/agg.mpg>
 - Movement of cells during morphogenesis <http://dictybase.org/Multimedia/development/culm.mov>
 - Dictyostelium development http://dictybase.org/Multimedia/development/Dd%20timelapse%206%20days_Kaks_onen.mp4
 - Prestalk cells in slugs <http://dictybase.org/Multimedia/morphogenesis/weijer1.avi>

Essential Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium discoideum</i> : molecular approaches to cell biology. <i>Volume 28 of Methods in Cell Biology</i> (Unit I, II, III)	James A Spudich	Academic Press

Suggested Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium</i> -A model system for cell and developmental biology (Unit I, II, III, IV)	Yasuo Maeda, Kei Inouye and Ikuo Takeuchi (Eds)	Universal Academic Press, Inc. Tokyo Japan
3	Research papers (Unit I, II, III, IV)		

DSE-GEN-405

Cancer Biology and Genetics

Course Objective: *Comprehensive genetic and molecular analysis of tumor progression and advances in technology, have contributed to our understanding of various pathways and molecules. These have been exploited for their therapeutic leading to considerable improvement in patient survival and management for some cancers. In this course, the students get familiar with various aspects of oncology with an emphasis on genetics, biology, diagnosis, prevention and therapy of cancers.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Cancer Biology and Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Epidemiology, etiology, diagnosis and molecular pathology of cancer	10
II	Mechanistic basis of oncogenesis	15
III	Biology of tumour progression	10
IV	Advances in cancer diagnostics and therapy	10
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Cancer Biology and Genetics’, the students would have:

- Developed a clear understanding of how cancers originate and are classified, and how various factors contribute to disease development and diagnosis.
- Gained insight into the biological mechanisms and genetic basis of cancer initiation, uncontrolled cell growth and tumor formation.
- Understood how tumors progress and spread, and how interactions with surrounding tissues and metabolism influence disease outcome.
- Appreciated the role of the immune system in controlling cancer and the strategies tumors use to escape immune recognition.
- Acquired an overview of modern approaches to cancer diagnosis and treatment, and how molecular knowledge has shaped current and emerging therapeutic strategies.

Content (Theory)**45 hours**

- I. Etiology and molecular pathology of cancer (10 hours)**
 - Pathology of tumor/cancer tissues
 - Classification of tumor/cancers; major cancer types
 - Approaches for cancer diagnostics and tumor markers
 - Molecular pathology -Molecular and diagnostic markers
 - Influence of environment and lifestyle changes
 - Broad overview of environmental, chemical, physical, infectious, genetic, and lifestyle risk factors; concept of multistep carcinogenesis and latency.
 - Cancer and Aging
- II. Mechanistic basis of oncogenesis (15 hours)**
 - Classical and new hallmarks of cellular transformation
 - Chromosomal rearrangements, Mutations, Aneuploidy
 - Genetic basis of oncogenesis – historical theories, discovery of tumor suppressors and oncogenes
 - Multistage tumorigenesis and tumor evolution
 - Hereditary and familial cancers
 - Viral theory of carcinogenesis- discovery of tumor suppressors and oncogenes
 - DNA repair defects and mutator hypothesis - Loss of heterozygosity analysis, allelotyping, microsatellite instability
- III. Biology of tumor progression (10 hours)**
 - Signalling pathways of cancer
 - Cancer progression: Metastatic cascade, Angiogenesis, Epithelial to mesenchymal transformation
 - Tumor microenvironment – Warburg effect, immune and other cells, inflammation and hypoxia
 - Role of immune system in preventing tumor growth
 - Acquired escape mechanisms against immune surveillance
 - Tumor antigens and T cell activation
- IV. Advances in cancer diagnostics and therapy (10 hours)**
 - Mutational signatures; driver and passenger mutations; heterogeneity
 - Cancer treatment modalities and assessment of prognosis
 - Targeted therapy and synthetic lethality
 - Mechanisms of resistance
 - Examples of cancer treatment and their evolution based on molecular and technological advances.

Content (Tutorials)**15 hours**

The tutorials in this course are designed to encourage the students to take a holistic approach to learning about cancer by understanding the role of the researcher, oncologist and the patient.

- Discussions on books such as:
 - a. Rebel Cell: Cancer, Evolution, and the New Science of Life's Oldest Betrayal by Kat Arney (Author) ISBN-13978-1950665303
 - b. The Emperor of All Maladies : A Biography of Cancer (Winner of the Pulitzer Prize for Non-fiction 2011) Edition2011 by Siddharth Mukherjee ISBN-13978-0007250929
 - c. The Immortal Life of Henrietta Lacks by Rebecca Skloot ISBN-13978-0330533447

- Discussions on original research articles on model systems (in vitro, in vivo and other organisms) for studying cancers, aging and its prevalence in the animal and plant kingdom
- Discussion on Nobel prize winning lectures and notes as available on nobelprize.org. Some of the noteworthy ones being
 - a. The Nobel Prize in Physiology or Medicine 1966 to Peyton Rous "for his discovery of tumour-inducing viruses" and Charles Brenton Huggins "for his discoveries concerning hormonal treatment of prostatic cancer"
 - b. The Nobel Prize in Physiology or Medicine 1975 to Dulbecco, Temin and Baltimore on mechanisms of tumor viruses
 - c. J. Michael Bishop - Nobel Prize lecture on 8 December 1989
<https://youtu.be/CDv77rmzKR4?si=bMvhS4RodpZMws3m>
 - d. James P. Allison delivered the lecture "Immune Checkpoint Blockade in Cancer Therapy: New insights, opportunities, and prospects for cures"
<https://www.youtube.com/live/slHiM-PBTJ8?si=QMPHUGtAYXI7JqXH>
- Discussion on individual contribution of 2019 The Nobel Prize in Physiology or Medicine on The von Hippel-Lindau Tumor Suppressor Gene: Insights into Oxygen Sensing and Cancer by William G. Kaelin Jr., Sir Peter J. Ratcliffe, and Gregg L. Semenza
- Discussions on seminal papers as well as current research papers related to the theoretical concepts

Essential reading:

1. The Biology of Cancer (Unit I, II, III, IV)	Robert A. Weinberg (Ed.)	Garland Sciences
2. Hallmarks of cancer (Unit II, III)	Hanahan and Weinberg	Cell, Cell Press 2011 https://doi.org/10.1016/j.cell.2011.02.013
3. The hallmarks of cancer (Unit II, III, IV)	Hanahan and Weinberg	Cell. Cell Press 2000 https://doi.org/10.1016/S0092-8674(00)81683-9

Suggested reading:

1. The Molecular Biology of Cancer (Unit II)	Pelengaris S, Khan M (Eds.)	Blackwell Publishing, Oxford
2. The Genetic Basis of Human Cancer (Unit II, III)	Vogelstein & Kinzler	McGraw-Hill
3. Review and research articles as suggested in class (Unit I, II, III, IV)		

DSE-GEN-406

Molecular Plant-Microbe Interaction

Course Objective:

Pathogenic microbes are a global threat not only to human health but also to food production and quality. With the ever-increasing demand to improve agricultural yields and keep up with global food demand, this area of host–microbe interaction is becoming increasingly important for sustainable agriculture. The interactions between microbes and plants provide fascinating examples of biological communication. The course is designed to understand the molecular intricacies underlying host–pathogen relationships and to apply these insights to develop sustainable strategies for enhanced disease resistance in crops.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-406 Molecular Plant-Microbe Interaction	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Introduction and Experimental methods used in plant pathology and biocontrol	10
II	Microbial pathogenicity: molecular basis and evolution	15
III	Plant defence mechanisms: Molecular interactions and cross-talks	15
IV	Deploying Disease resistance strategies for sustainable agriculture	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Molecular plant-microbe interactions’, the students would have:

- Developed a foundational understanding of plant–microbe interactions and their importance for plant health and sustainable crop production.
- Gained insight into the molecular basis and evolution of microbial pathogenicity
- Understood the key components of plant defence systems and the complex molecular cross-talk involved in immunity.
- Learned how plants distinguish between pathogenic and beneficial microbes at the molecular and cellular levels.
- Acquired an appreciation of emerging disease resistance strategies and biotechnological approaches for sustainable agriculture.

Content (Theory)**45 hours**

- I. **Introduction to plant-microbe interaction** (10 hours)
 - A historical perspective on the significance of plant health and current challenges to sustainable crop production, including beneficial microbes.
 - Introduction to central concepts underlying host-microbe interactions- pathogenic and symbiotic interactions
 - Genomic tools, molecular and cellular genetics, imaging for bacteria, fungi and oomycetes

- II. **Microbial pathogenicity: Molecular basis and evolution** (15 hours)
 - Pathogenesis concepts and definition, Molecular determinants of bacterial and fungal pathogenicity: effectors, elicitors, plant cell wall-degrading enzymes, host-specific toxins, host non-specific toxins, small RNA.
 - Beneficial microbes

- III. **Plant defence mechanisms: Molecular interactions and cross-talks** (15 hours)
 - Non-host resistance, Plant innate immunity, Pre-formed inhibitors of pathogen invasion
 - R genes (quantitative and monogenic resistance)
 - Guards and Decoys
 - Role of mobile small RNAs
 - Systemic acquired resistance.
 - How do plants differentiate good microbes from the bad guys

- IV. **Emerging Disease resistance strategies for sustainable agriculture** (5 hours)
 - Translational research advances and potentials:
 - Application of biotechnological tools, including genomics (NGT), transcriptomics, molecular genetics, gene editing (e.g. CRISPR-Cas9), and gene silencing (PTGS, HIGS, etc.)
 - Application of microbes for improving plant health

Content (Tutorials)**15 hours**

- Addressing individual queries on class concepts
- Discussing relevant video content exemplified by :
 - How plant immune systems protect them from disease by Prof Jonathan DG Jones, The Sainsbury Lab
<https://www.youtube.com/watch?v=uVd1CYZDhnU>
 - Understanding the amazing ways plants defend themselves through videos by Prof Sheng-Yang-He
[Sheng-Yang He \(Michigan State U. and HHMI\) 1: Introduction to Plant-Pathogen Interactions - YouTube](#)
[Sheng-Yang He \(Michigan State U. and HHMI\) 2: The effect of climate on plant disease](#)

- Strategies for resistance to plant virus diseases
<https://www.youtube.com/watch?v=B82UmkOAgd8>

Discussing the related review articles:

- The plant immune system: From discovery to deployment (2024) Cell, Volume 187, Issue 9, 2095 - 2116
- Pathogen perception and signalling in plant immunity,(2024) Plant cell 36: 1465-1481
- Pattern-recognition receptors are required for NLR-mediated plant immunity (2021) Nature Plants: **7**, pages 382–383
- Receptor networks underpin plant immunity (2018) Science; 360: 6395, pp. 1300-1301
[DOI: 10.1126/science.aat2623](https://doi.org/10.1126/science.aat2623)
- Plant-Pathogen Effectors: Cellular Probes Interfering with Plant Defenses in Spatial and Temporal Manners (Annu Rev Phytopathol, 2016) 54:419-441.
- Action Mechanisms of Effectors in Plant-Pathogen Interaction. Int. J. Mol. Sci. 2022, 23, 6758. <https://doi.org/10.3390/ijms23126758>
- Susceptibility genes 101: How to be a good host Annual Review of Phytopathology (2014) 52:551–81.

Essential Readings

Plant Pathology (Unit I, II, III, IV)	Agrios GN	Academic Press
Recent Reviews and research paper		

Suggested Readings

Molecular Plant pathology (Unit I, II, III, IV)	Dickinson M	BIOS Scientific Press
Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions (Unit I, II, III, IV)	Jeng-Sheng HT	Kluwer Academic Publ.

DSE-GEN-407**Yeast Genetics**

Course Objective: *The course is designed to provide some fundamental principles on which to form an integrated view of various genetic and molecular processes using yeast as a model system. Tutorials would be in the form of discussion based on primary literature available related to each topic, highlighting the advances in each field.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-407 Yeast Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	The Yeast Genome and Functional Genomics	10
II	Mitochondrial Biology and Nuclear–Mitochondrial Communication	15
III	Nutrient Sensing, Signaling, and Yeast Longevity	15
IV	Protein-Based Inheritance and Pathogenicity in Yeasts	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing 'Yeast Genetics', the students would have:

- Developed a clear understanding of the yeast genome as a model system and its significance in modern genetics and cell biology.
- Gained insight into genome-wide approaches of the post-genomic era for studying gene function and cellular organization.
- Understood the principles of mitochondrial structure and dynamics and their regulation within the cell.
- Learned how mitochondrial function and gene expression are coordinated with the nuclear genome.
- Acquired the ability to integrate genomic and mitochondrial processes to explain cellular adaptation and signaling.

Content (Theory)**45 hours****I. The Yeast Genome and Functional Genomics (10 hours)**

- Structure and organization of the yeast genome
- overview of life processes
- life with 6000 genes
- Advances in the post-genomic era :genome-wide microarray analysis, proteomics, and global protein localization studies.
- Functional genomics approaches : synthetic gene array analysis and large-scale genome engineering projects including SC2.0.

II. Mitochondrial Biology and Nuclear–Mitochondrial Communication (15 hours)

- Mitochondrial physiology in yeast
- Organelle dynamics, fusion and fission processes.
- Regulation of mitochondrial function by the nuclear genome
- mechanisms of mitochondrial gene expression
- Retrograde signaling pathways
- coordination between mitochondrial activity and nuclear gene expression.

III. Nutrient Sensing, Signaling, and Yeast Longevity (15 hours)

- Concepts of chronological and replicative life span in yeast
- Effects of environmental and nutritional cues, including calorie restriction and amino acid starvation, on cellular longevity
- Nutrient-dependent signaling pathways such as TOR signaling
- transcriptional regulation mediated by GCN4.

IV. Protein-Based Inheritance and Pathogenicity in Yeasts

- Prions in yeast as epigenetic elements,
- inheritance patterns, propagation mechanisms, de novo formation, structural features, and biological consequences of prions
- Overview of pathogenic yeasts and associated diseases, with an introduction to *Candida albicans*.
- Comparative analysis of *Saccharomyces cerevisiae* and *Candida albicans* focusing on mating types, mitochondrial physiology, and carbon utilization strategies.

Content (Tutorials)**15 hours**

- Addressing individual queries on class concepts
- Discussing research papers on the power of budding yeast: The Yeast Genome and Functional Genomics
- The Power of Yeast <https://doi.org/10.1002/yea.70009>
- Nobel Yeast Research <https://doi.org/10.1093/femsyr/fow094>
- The art and design of genetic screens: yeast <https://doi.org/10.1038/35088500>
- Discussing research papers on Mitochondrial Biology and Nuclear–Mitochondrial Communication
- The Warburg and Crabtree effects: On the origin of cancer cell energy metabolism and of yeast glucose repression <https://doi.org/10.1016/j.bbabi.2010.08.010>
- Nucleus to Mitochondria: Lost in Transcription, Found in Translation <https://doi.org/10.1016/j.devcel.2016.06.003>
- Synchronized mitochondrial and cytosolic translation programs <https://doi.org/10.1038/nature18015>
- Discussing research papers on Nutrient Sensing, Signaling, and Yeast Longevity
- The power of yeast genetics applied to the powerhouse of the cell <https://doi.org/10.1016/j.tem.2014.12.002>

- Replicative and Chronological Aging in *Saccharomyces cerevisiae*
<http://dx.doi.org/10.1016/j.cmet.2012.06.002>
- Mitochondrial quality control during inheritance is associated with lifespan and mother–daughter age asymmetry in budding yeast <https://doi.org/10.1111/j.1474-9726.2011.00731.x>
- Mitochondrial anchorage and fusion contribute to mitochondrial inheritance and quality control in the budding yeast *Saccharomyces cerevisiae* <https://doi.org/10.1091/mbc.E15-07-0455>
- Discussing research papers on Protein-Based Inheritance and Pathogenicity in Yeasts
- Prions in Yeast <https://doi.org/10.1534/genetics.111.137760>
- Yeast Prions: Structure, Biology, and Prion-Handling Systems
<https://doi.org/10.1128/mubr.00041-14>

Essential Readings

- | | | | |
|----|--|---------------------------|-------------------------|
| 1. | Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit I, II, III, IV) | Guthrie C & Fink GR(Eds.) | Elsevier Academic Press |
|----|--|---------------------------|-------------------------|

Suggested Readings

- | | | | |
|----|---|----------------------------------|-------------|
| 1. | Getting started with yeast, Methods Enzymol. Vol. 350, pp. 3-41 (2002) (Unit I, II) | Sherman F | |
| 2. | Yeast Research: A Historical Overview (Unit I, II, IV) | James A. Barnett & Linda Barnett | A S M Press |

SEMESTER 4; S1

GENERAL ELECTIVE

2Y-PG

GE-GEN-410**Basic Science to Biological Application****Course Objective:**

The root of fascinating technological advances in biological science is in the basic science research with no inkling of future possibilities. Whether serendipitous or planned, this concept of blue sky research has contributed tremendously to advancement in science. This general elective aims to illuminate the students with the excitement of doing basic science research particularly in the light of their subsequent usage in biological application.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-410 Basic Science to Biological Application	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Discoveries related to Nucleic acids	6
II	Discoveries related to Gene regulation	11
III	Discoveries related to cell biology	16
IV	Discoveries related to Protein Science	7
Tutorials		
Various modalities as given below		15

Course outcomes : On completing ‘Basic Science to Biological Applications’, the students would have:

- Developed an understanding of key discoveries in nucleic acid biology and how they transformed genome manipulation and functional analysis.
- Gained insight into major breakthroughs in gene regulation and molecular tools that enable controlled gene expression and interaction studies.
- Understood landmark discoveries in cell biology that led to modern plant transformation and biotechnological applications.
- Learned how advances in protein science have shaped structure prediction and functional analysis.
- Appreciated how foundational biological discoveries translate into real-world applications such as drug discovery therapeutic protein production and regenerative biology.

Content (Theory)**45 hours****I. Discoveries related to Nucleic acids (6 hours)**

- RNA interference
- Genome editing: CRISPER TALEN
- Transposon discovery to applications

II. Discoveries related to Gene regulation (11 hours)

- The regulatable promoter
- Yeast 2-hybrids
- Phage display (antibody) Gibson assembly
- Gateway cloning
- Yamanaka factors to stem cell reprogramming

III. Discoveries related to cell biology (16 hours)

- *Agrobacterium tumefaciens* mediated crown gall formation to plant transformation
- *Agrobacterium rhizogenes* mediated hairy roots to secondary metabolite production

IV. Discoveries related to Protein Science (7 hours)

- Crystallography to Alpha fold
- examples in Drug discovery applications
- Secretion pathway discovery to Insulin production

Content (Tutorial)**15 hours**

- **Addressing individual queries on class concepts**
- **Discussing research papers on discoveries related to Nucleic acids**
 - RNA Interference: Big Applause for Silencing in Stockholm
<https://doi.org/10.1016/j.cell.2006.12.001>
 - Introduction of a Chimeric Chalcone Synthase Gene into Petunia Results in Reversible Co-Suppression of Homologous Genes in trans
<https://doi.org/10.1105/tpc.2.4.279>
 - Flavonoid genes in petunia: addition of a limited number of gene copies may lead to a suppression of gene expression <https://doi.org/10.1105/tpc.2.4.291>
 - The new frontier of genome engineering with CRISPR-Cas9
<https://doi.org/10.1126/science.1258096>
- **Discussing research papers on discoveries related to Gene regulation**
 - Yeast Gal4: a transcriptional paradigm revisited
<https://doi.org/10.1038/sj.embor.7400679>
 - The evolution of the GALactose utilization pathway in budding yeasts
<https://doi.org/10.1016/j.tig.2021.08.013>
 - Studies on the positive regulatory gene, GAL4, in regulation of galactose catabolic enzymes in *Saccharomyces cerevisiae* <https://doi.org/10.1007%2F2F00268616>
 - GAL4 system in drosophila: A fly geneticist's swiss army knife
<https://doi.org/10.1002%2Fgene.10150>
 - Separation of DNA Binding from the Transcription-Activating Function of a Eukaryotic Regulatory Protein <https://doi.org/10.1126/science.3080805>

- **Discussing research papers on discoveries related to cell biology**
 - Beyond My Wildest Expectations (A review by Eugene Nester regarding discovery of plant transformation) <https://doi.org/10.1146/annurev-micro-091313-103703>
 - Agrobacterium tumefaciens: From crown gall tumors to genetic transformation <https://doi.org/10.1016/j.pmpp.2011.06.004>
 - Agrobacterium tumefaciens: a Transformative Agent for Fundamental Insights into Host-Microbe Interactions, Genome Biology, Chemical Signaling, and Cell Biology <https://doi.org/10.1128/jb.00005-23>
- Discussing relevant video and popular blog content exemplified by
 - The CRISPR Apostle: Rodolphe Barrangou <https://www.youtube.com/watch?v=7qS2fjeVzsk>
 - Nobel winners Doudna, Charpentier discover how CRISPR Cas9 gene editing works <https://youtu.be/cuHD7jCY8X4>
 - Tinkering with Nature's Tools: The CRISPR Pioneer Feng Zhang <https://youtu.be/x4o6IINr7pc>
 - Scientist Stories: Shinya Yamanaka, Cell reprogramming and Pioneering Induced Pluripotent Stem Cells <https://youtu.be/c5DxfekDGk>
- Discussing relevant popular blog/content online exemplified by
 - Biographical Overview | Barbara McClintock - Profiles in Science <https://profiles.nlm.nih.gov/spotlight/l/>
 - Barbara McClintock and the Discovery of Jumping Genes (Transposons) <https://www.nature.com/scitable/topicpage/barbara-mcclintock-and-the-discovery-of-jumping-34083/>
 - Stem Cell Reprogramming <https://iscrm.uw.edu/what-is-cell-reprogramming/>

Essential Reading

- | | | | |
|----|--|----------------------|----------------------------|
| 1. | The Gene: An Intimate History
(Unit I, II, III, IV) | Siddhartha Mukherjee | Penguin Random House India |
|----|--|----------------------|----------------------------|

Suggested Readings

1.	The Gene: An Intimate History (Unit I, II, III, IV)	Siddhartha Mukherjee	Penguin Random House India
2.	The Song of the Cell: An Exploration of Medicine and the New Human (Unit III)	Siddhartha Mukherjee	Bodley Head
3.	The Double Helix (Unit 1, II, IV)	James D. Watson	Atheneum Publishers in New York
4.	Gene Machine (Unit II, IV)	Venki Ramakrishnan	Basic Books

SEMESTER 4; S1

SKILL BASED COURSE

2Y-PG

SBC-GEN-411

Scientific Writing and Presentation

Course Objective:

Scientific writing is a crucial skill for researchers, enabling them to communicate their findings effectively. This course is designed to help students develop a structured approach to writing research papers, reviews, and grant proposals. It will cover the essential components of scientific manuscripts, ethical considerations, and the nuances of publishing in reputed journals. Additionally, students will learn how to create impactful scientific presentations and posters. The course emphasizes clarity, coherence, and precision, ensuring that students can present their research in a compelling manner.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-411 Scientific Writing and Presentation	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		Teaching
I	Fundamentals	10
II	Ethics in scientific publishing and research	5
Practical		
I	Theory to practice -Short seminar presentation	15
II	Theory to practice -Designing scientific posters	15

Course outcome: At the end of the 'Scientific Writing and Presentation' course the students would have

- Understood the fundamental decision making of what to write under different sections of a scientific document
- Developed a strong understanding on good ethics to be implemented while writing a scientific document
- Recognized the importance of honest, impactful presentation of scientific content

Content (Theory)**15 hours****I. Fundamentals (10 hours)**

- Importance of scientific writing in research and academia
- Differences between scientific and general writing
- Common challenges faced by researchers in scientific communication
- Writing for different audiences: academia, industry, and the general public.
- Structure of scientific research papers
- Writing an effective abstract and selecting appropriate keywords
- Crafting a compelling introduction and research rationale
- Choosing a suitable title for maximum impact.
- Differences between research articles, narrative reviews, and systematic reviews
- Strategies for summarizing large volumes of literature
- Structuring a review article effectively
- Best practices for citation management and referencing.
- Components of a research proposal
- Writing a strong research rationale and hypothesis
- Budgeting and financial justification in grants
- Identifying funding opportunities and understanding the evaluation process.
- Designing impactful PowerPoint slides and scientific posters
- Techniques for delivering effective oral presentations
- Handling Q&A sessions confidently during conferences and thesis defenses
- Common mistakes to avoid in scientific presentations.

II. Ethics in scientific publishing and research (5 hours)

- Understanding plagiarism and ways to avoid it
- Criteria for authorship and handling conflicts of interest
- The peer-review process
- responding to reviewer comments
- Choosing the right journal and avoiding predatory publishers.

Content (Practical)**30 hours****I. Theory to practice -Short seminar presentation**

Students will be mentored and asked to make seminar presentations in the department

II. Theory to practice -Designing scientific posters

Students will be mentored and asked to make scientific posters to teach them responsible dissemination of scientific content and enthuse them towards 'science for society'

Essential readings

- | | | | |
|----|---|-----------------|-----------|
| 1. | The Craft of Scientific Writing
(Unit I, II) | Alley, M (2018) | Springer. |
|----|---|-----------------|-----------|

Suggested Readings:

- | | | | |
|----|--|-------------------------|----------------------------|
| 1. | The Craft of Scientific Writing
(Unit I, II) | Alley, M (2018) | Springer. |
| 2. | Science Research Writing: A Guide for
Non-Native Speakers of English.
(Unit I) | Glasman-Deal, H. (2010) | Imperial College
Press. |
| 3. | Writing Science: How to Write Papers
That Get Cited and Proposals That Get
Funded (Unit I, II) | Schimel, J. (2012) | Oxford University
Press |

**TWO YEAR
MASTERS IN GENETICS
POST GRADUATE PROGRAMME**
Structure 2
(Semester 3 & 4 effective from 2026)



**DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS**

MSC GENETICS – TWO YEAR DEGREE PROGRAM

Course Structure and Credits Overview

Students enter into this program after three years of graduation from any discipline in Science through an entrance exam only. After completion of their one year (Semester 1 & 2), which is exactly the same for all 2 year PG students- they will enter into three possible Structures in their second year (Semester 3 & 4) as prescribed by the University.

Their entry into these Structures will be in consultation with the Department based on available infrastructure, facilities and teaching faculty. These structures have been prescribed based on the distribution of core (C), elective (E), 2 credit course skill based course (2c/SBC) and research project (R) component. Our department has been keeping experimental training in the forefront of our Masters programs enabling our students to seek research as a career option. Therefore, we have incorporated our experimental training based on the theory being taught as a Core subject wherever permissible. The credits under each course type are divided into Theory/Lecture (L), Practical (P) and Tutorial (T) as per the norms shared by the University. The division is shown along with the course content of every semester.

1 credit = 15 hours of teaching/30 hours of practical/15 hours of tutorials

Distribution Of Course Type Credits Under Each Structure When The Students Exit Msc Genetics (2Y) Program

	Core	Elective	2 credit courses	Research project	Credits earned at exit of MSc-2Y PG
Structure 1	40	40	8	0	88
Structure 2	40	32	4	12	88
Structure 3	28	24	10	26	88

Overview Of The Structures Available To Msc. Genetics (2Y Program) – Semester-Wise Distribution

	Semester 1 (same courses for all)				Semester 2 (same courses for all)				Semester 3				Semester 4				Total credits
	C	E	2c	R	C	E	2c	R	C	E	2c	R	C	E	2c	R	
Structure 1	12	8	2	0	12	8	2	0	8	12	2	0	8	12	2	0	88
Structure 2	12	8	2	0	12	8	2	0	8	8	0	6	8	8	0	6	88
Structure 3	12	8	2	0	12	8	2	0	4	4	4	10	0	4	2	16	88

C: Core; E: Elective (Discipline specific/Open); 2c (2 credit core courses); R: Research project

Note regarding Electives:

Elective courses are either Discipline specific elective (DSE, offered by the department of genetics) or general elective (GE, offered by other departments) Students can either opt for all DSE offered by its own department or opt for ANY ONE of the GE by other department in addition to other DSE(s) to complete their quota of electives in a particular semester.

Two year MSc Genetics, 2Y-PG Structure 2 (Coursework + Research)

Course Code	Type/credit	Title	
Semester 1			
DSC-GEN-101	DSC/4	Biological Processes and Patterns of Inheritance	Compulsory
DSC-GEN-102	DSC/4	Genes, Genome and Chromosomes	
DSC-GEN-103	DSC/4	Experiential learning in Genetics- I	
DSE-GEN-104	DSE/4	Molecular Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-105	DSE/4	Cell Biology	
DSE-GEN-106	DSE/4	Enzymology and Metabolism	
GE-GEN-110	GE/4	Genetics in Crop Improvement (offered only to students of other departments)	
SBC-GEN-111	SBC/2	Statistical Analysis in Biology	Compulsory
Semester 2			
DSC-GEN-201	DSC/4	Regulation of Gene Expression	Compulsory
DSC-GEN-202	DSC/4	Recombinant DNA Technology	
DSC-GEN-203	DSC/4	Experiential learning in Genetics- II	
DSE-GEN-204	DSE/4	Developmental Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-205	DSE/4	Immunology and Immunogenetics	
DSE-GEN-206	DSE/4	Mitochondrial Biology and Connection to Cell Physiology	
GE-GEN-210	GE/4	Genetics in Everyday Life: From DNA to Society (offered only to students of other departments)	
SBC-GEN-211	2CC/2	Microscopy and Imaging	Compulsory
Semester 3			
DSC-GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
DSC-GEN-303	DSC/4	Genetics of Microorganisms	
DSE-GEN-304	DSE/4	Plant Genetics and Breeding	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-305	DSE/4	Human Genetics	
GE-GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
RP-GEN-313-S2	RP/6	Research Project	Compulsory
Semester 4			
DSC-GEN-401	DSC/4	Population and Quantitative Genetics	Compulsory
DSC-GEN-402	DSC/4	Application of genetic studies in clinical research and plant biotechnology	
DSE-GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-404	DSE/4	Biology of Dictyostelium	
DSE-GEN-405	DSE/4	Cancer Biology and Genetics	
DSE-GEN-406	DSE/4	Molecular plant-microbe interaction	
DSE-GEN-407	DSE/4	Yeast genetics	
GE-GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
RP-GEN-413-S2	RP/6	Research Project	Compulsory

SEMESTER 3 (2Y-PG)

Structure 2-Coursework +Research

Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	2	2 (2DSE+0GE; 1DSE+1GE)	0	1	5
Credits	8	8	0	6	22
Student needs to complete 8+8+0+6 = 22 credits					

Course Distribution and Overview

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSC-GEN-301	DSC	Principles of Genetic analysis	4	3	1	0
DSC-GEN-303	DSC	Genetics of microorganisms	4	3	1	0
DSE-GEN-304	DSE	Plant Genetics & Breeding	4	3	0	1
DSE-GEN-305	DSE	Human Genetics	4	3	0	1
GE-GEN-310	GE	Genetics in Human Health	4	3	0	1
RP-GEN-313-S2	RP	Research Project	6	0	6	0

1 credit = 15 hours of teaching/ 30 hours of practical/ 15 hours of tutorials

SEMESTER 3; S1

DISCIPLINE SPECIFIC CORE

2Y-PG

DSC-GEN-301

Principles of Genetic Analysis

Course Objective: The paper on Genetic Analysis builds upon the foundation laid by Biological Processes and Inheritance Patterns, taught in Semester I, or equivalent courses from undergraduate programs in the four-year curriculum. Unit 1 is structured to reinforce the fundamental concepts of genetic analysis introduced earlier, with a strong emphasis on self-reading and assignments to deepen understanding. Recognizing the diverse methodologies available for genetic analysis in different organisms the subsequent units 2 and 3 focus on outlining essential concepts rather than detailing specific analytical instances. These topics will be enriched with case studies, and the mentor will select the specific examples most relevant for discussion. Unit 4 is introductory in nature and will be covered in details in other papers.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-301 Principles of Genetic Analysis	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Recap of key concepts	8
II	Power of genetic analysis	20
III	Of maps and distances	10
IV	Genes and Populations	7
Practical		
I	Studying inheritance in bacteria through conjugation	15
II	Studying inheritance in eukaryotes using appropriate model system	15

Course outcomes : On completing 'Principles of genetic analysis', the students would have:

- Developed a strong conceptual foundation in genetic variation and inheritance patterns
- Gained an understanding of how genetic analysis is employed in different model systems to reveal gene function and biological pathways
- Learned how mutations are generated, identified and analyzed to connect phenotypes with underlying genes.
- Understood the principles and purpose of genetic and physical mapping in locating genes and interpreting recombination.
- Acquired insight into the genetic analysis of populations and complex traits using natural variation and genome-wide approaches.

Content (Theory)**45 hours****I. Recap of key concepts (8 hours)**

- Variations : key to genetic analysis
- Cellular and Molecular basis of inheritance patterns
- Epistasis and Genetic pathways
- Probability and statistics in genetic analysis
- Societal impact of genetics

II. Power of genetic analysis (20 hours)

- Pros and cons of different systems: e.g. Viruses, bacteria, yeast, *C. elegans*, *Drosophila*, *Arabidopsis*, mouse, humans
- Mutations: Generating, finding and classifying mutants
- Assigning mutants to genes - complementation test
- Phenotype to DNA sequence – Forward Genetics
- Cloned genes to mutant phenotype – Reverse Genetics
- Genome-wide mutant screens

III. Of maps and distances (10 hours)

- The classical mapping strategy: Three-point test cross and fine structure mapping of genes- what do they teach us?
- Temporal and recombination maps
- Physical versus Genetic maps
- Mapping genes to chromosomes
- Why create maps ?

IV. Genes and Populations (7 hours)

- Genome wide associations
- Genetic analysis of complex traits
- Genetic analysis using natural variations

Content (Practical)**30 hours****I. Studying inheritance in bacteria through conjugation**

- Setting up crosses bacterial crosses using differing recipient strains of *E. coli*
- Recovery of ex-conjugates using media designed to screen for respective markers present in the donor
- Confirmation experiments of successful conjugation using F+ and F – strains of *E. coli*

II. Studying inheritance in eukaryotes using appropriate model system

- Students will be given experiential training in analyzing segregating population of *Arabidopsis*/ seeds to understand basic principal of independent assortment and segregation
- Statistical analysis of generated data (from above) using chi square test

Essential Reading

1.	Genetics: Analysis: Genes, genomes and Networks (Unit I, II, III, IV)	Meneely P	2 nd Edition Oxford University Press
2.	Introduction to Genetic Analysis (Unit I, II, III, IV)	Griffiths A JF et al	12 th Edition Macmillan International Higher Education

Suggested Reading

1.	Genetics: Principles and Analysis (Unit I, II, III, IV)	Hartl DL and Jones EW	Jones and Bartlett Publishers
2.	Concepts of Genetics (Unit I, II, III, IV)	Klug W, Cummings MR, Spencer CA, Palladino MA	Pearson Publishing
3.	Genetics of Bacteria (Unit II)	Srivastava S	Springer Nature
4.	Research papers as suggested by the teacher (Unit I, II, III, IV)		

DSC-GEN-303

Genetics of Microorganisms

Course Objective: *Microorganisms have occupied a significant space in the field of not just genetics but also immunology and biochemistry. Combining the structural simplicity with the unifying genetic basis, they offered immediate advantages in studying all the three aspects of heredity: the generation, expression, and transmission of biological variation. This paper deals with the strength of microbial genetics: both prokaryotic as well as eukaryotic.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-303 Genetics of Microorganisms	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Classical genetics in microbes	10
II	Molecular genetics and tools	8
III	Art and design of genetic screens	18
IV	Quorum sensing and immunity in bacteria	9
Practical		
I	Isolation of suppressors of yeast mutants defective for cellular respiration	15
II	Determination of whether suppressor mutation has a cytoplasmic or nuclear pattern of inheritance	15

Course outcomes : On completing ‘Genetics of Microorganisms’, the students would have:

- A clear understanding of how genes are transferred and mapped in bacteria and how bacteriophages contribute to genetic recombination and regulation.
- Working knowledge of molecular genetics tools using eukaryotic model microbe, yeast as a model system for identification gene function, cloning, expression control, and genome manipulation.
- The ability to design and interpret genetic screens to uncover gene function and genetic interactions in cellular pathways.
- An integrated understanding of quorum-sensing, bacterial signal transduction, biofilm formation and regulation, immune strategies in bacteria.
- Practical experience in genetic screening and inheritance analysis using yeast to distinguish nuclear and cytoplasmic genetic control.

Content (Theory)**45 hours**

- I. **Classical Genetics in Microbes** (10 hours)
 - Conjugation - Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination
 - Chromosome transfer in other bacteria
 - Transformation- Natural transformation systems, biology and mechanism of transformation, transformation and gene mapping, chemical-mediated and electro-transformation
 - Transduction: Discovery, generalized and specialized or restricted transduction, phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction;
 - Temperate phage lambda and mechanism of specialized transduction
 - Gene mapping, Fine-structure mapping
 - Techniques for studying bacteriophages- Virulent phage (T4) and temperate phage (phage lambda)
 - Important aspects of lytic cycle, phage-host relationships, immunity and repression site specific recombination (lambda and P1).
- II. **Molecular genetics and tools** (8 hours)
 - Yeast as an experimental system for eukaryotic molecular biology
 - Yeast cloning and expression vectors
 - Regulatable promoters
 - Construction of genetically modified strains
 - Generation of conditional alleles
 - Cosmids and yeast artificial chromosomes
 - Yeast one-, two- and three-hybrid systems
 - Mating-Type Genes and MAT Switching in *Saccharomyces cerevisiae*, HML, HMR and MAT loci, HO endonuclease, regulation of switching.
- III. **Art and design of genetic screens** (18 hours)
 - Choice of mutant phenotypes
 - Cloning by complementation
 - Isolation of bypass and allele specific-suppressors
 - Synthetic lethal screens
 - Use of these tools to isolate genes in the protein secretion pathway in yeast.
- IV. **Quorum sensing and immunity in bacteria** (9 hours)
 - Examples from *Vibrio harveyi* and *Vibrio fischeri*
 - Regulation of biofilm formation in *Vibrio cholera*
 - Two component signal transduction system
 - Discovery of CRISPR-Cas and its role in bacterial immunity.

Content (Practical)**30 hours**

- I. Isolation of suppressors of yeast mutants defective for cellular respiration

Hands-on training to screen for suppressor of yeast cells defective for growth on glycerol/ethanol, i.e., carbon sources required for cellular respiration.

- II. Determination of whether suppressor mutation has a cytoplasmic or nuclear pattern of inheritance
- In the isolated suppressor mutants that can reverse the growth defects on glycerol as the sole carbon source we will determine whether the mutation is present on the nuclear or mitochondrial DNA.
 - Suppressors identified will be crossed to ρ° cells of the opposite mating type. The ability of the resulting diploid to utilize glycerol as a carbon source will be determined to establish whether suppressor mutation is recessive or dominant/mitochondrial.
 - To distinguish whether the mutation is nuclear dominant or on mtDNA, the suppressor cells will be plated on ethidium bromide (EtBr) to remove mtDNA, followed by mating with ρ^{+} cells.
 - The ability of these diploids will indicate whether the suppressor identified is due to a nuclear dominant mutation or mutation in the mtDNA .

Essential Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.

Suggested Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.
3.	Modern Microbial Genetics (Unit II, III)	Streips U N & Yasbin RE	Wiley-Liss
4.	Molecular Genetics of Bacteria (Unit I)	Sneider L & Champness W	ASM Publishers
5.	Genetics of Bacteria (Unit I)	Scaife J	Academic Press
6.	Genetics of Bacteria and Viruses (Unit I)	Birge EA	Springer
7.	Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit II, III)	Guthrie C & Fink GR (Eds.)	Elsevier

DSE-GEN-304

Plant Genetics and Breeding

Course Objective: This course introduces students to the classical and contemporary principles of plant genetics and breeding. It covers natural breeding systems, gene pools, chromosome manipulation, heterosis, and conventional breeding strategies, while integrating advanced genomic and quantitative approaches, including QTL mapping, GWAS, genomic selection, phenomics, G×E analysis, and gene-editing-enabled breeding. The course is designed to provide a holistic understanding of how modern plant breeding combines genomics, statistics, and biotechnology to accelerate crop improvement and generate climate-resilient, high-yielding varieties.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-304 Plant Genetics and Breeding	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Historical perspective	4
II	Natural and conventional breeding strategies for trait introgression	13
III	Cytogenetic and chromosome manipulation approaches	5
IV	Molecular/genomics-assisted and heterosis breeding for crop improvement	23
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Plant Genetics and Breeding', the students would have:

- A clear understanding on tracing the historical development of plant breeding from early domestication to molecular and genomic eras and assess the importance of germplasm resources
- Learnt about Natural Breeding Systems, and Conventional Breeding Approaches
- Developed the aptitude for developing cytogenetic approaches and chromosome engineering
- Acquired the ability to apply basic concepts for molecular and genomics-assisted breeding

Content (Theory)**45 hours****I. Historical perspective (4 hours)**

- Importance and evolution of plant breeding.
- Major milestones: Mendelian genetics, chromosomal theory, quantitative genetics, Green Revolution, hybrid breeding.
- Transition from classical breeding to molecular and genomic eras.
- Role of genetic diversity and domestication in crop improvement.

II. Natural/conventional breeding methods and the gene pool concept (13 hours)

- Modes of reproduction in crop plants; self-pollination, cross-pollination, mixed mating, and apomixis.
- Consequences of breeding systems for homozygosity, heterozygosity, genetic load, and population structure.
- Applications of breeding systems in designing breeding strategies, including for climate-resilient cultivar development.
- Gene pool concept (primary, secondary, tertiary) and its relevance to trait introgression.
- Germplasm of major crops: cultivated types, landraces, wild relatives; pre-breeding strategies.
- Breeding methods for self-pollinated crops: mass selection, pure-line selection, pedigree method, bulk method, single-seed descent.
- Breeding methods for cross-pollinated crops: recurrent selection (simple, reciprocal, half-sib, full-sib), synthetic and composite varieties.
- Breeding vegetatively propagated crops: clonal selection and improvement strategies.

III. Cytogenetic and chromosome manipulation approaches (5 hours)

- Haploidy and doubled haploidy: production methods and use of DH lines in breeding.
- Polyploidy: auto- and allopolyploids, chromosome doubling, and applications in crop improvement.
- Wide hybridization: barriers to interspecific/intergeneric crosses and methods to overcome them (embryo rescue, ovule culture).
- Cytogenetic tools: karyotyping, meiotic pairing analysis, alien addition and substitution lines, induced translocations, and chromosome engineering.
- Applications of cytogenetic approaches in transferring stress-tolerance and other traits from wild relatives.

IV. Molecular/genomic and heterosis plant breeding (23 hours)

- Concepts and theories of heterosis at genetic, biochemical, and molecular levels.
- Combining ability (general and specific), heterotic groups and patterns.
- Hybrid breeding systems: CMS, GMS, TGMS; restorer lines; hybrid seed production technology.
- Molecular markers (SSR, SNP, indels): principles, strengths, limitations, and applications.
- Genetic linkage, mapping functions, and mapping populations (F_2 , RILs, NILs, DHs).
- Linkage mapping and QTL analysis: detection, effect estimation, and fine mapping.
- Association mapping/GWAS: linkage disequilibrium, population structure, and correction for confounding.

- Quantitative genetic parameters relevant to molecular/genomics-assisted breeding: heritability, genetic variances, and response to selection.
- Marker-assisted selection (MAS), marker-assisted backcrossing (MABC), and strategies for minimizing linkage drag; Marker-assisted recurrent selection (MARS) and gene pyramiding for complex traits.
- Genomic selection (GS) and genomic prediction: training populations, statistical models, validation, and deployment.
- Role of phenomics, multi-environment testing, and genotype × environment interactions in genomics-assisted breeding.
- Integration of gene editing (CRISPR/Cas), speed breeding, and high-throughput phenotyping into modern breeding pipelines.
- Use of integrative genomic approaches for developing climate-smart cultivars.

Content (Tutorial)

15 hours

- **Addressing individual queries and clarifying concepts from lectures.**
- **Discussion of classical and modern research papers in plant genetics and breeding (e.g., success stories of hybrid development, QTL mapping, MAS, and GS). These include, but are not limited to:**
 - Doebley, J. F., Gaut, B. S., & Smith, B. D. (2006). The molecular genetics of crop domestication. *Cell*, 127(7), 1309–1321. doi: 10.1016/j.cell.2006.12.006
 - Forster, B. P., & Thomas, W. T. B. (2005). Doubled haploids in genetics and plant breeding. *Plant Breeding Reviews*, 25, 57–88. doi: 10.1002/9780470650301.ch3
 - Meuwissen, T. H. E., Hayes, B. J., & Goddard, M. E. (2001). Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, 157(4), 1819–1829. doi:10.1093/genetics/157.4.1819
 - Yu, J., Pressoir, G., Briggs, W. H., et al. (2006). A unified mixed-model method for association mapping that accounts for multiple levels of relatedness. *Nature Genetics*, 38(2), 203–208. doi: 10.1038/ng1702
- **Problem-solving sessions on designing breeding schemes, calculating basic quantitative genetic parameters, and interpreting mapping results.**
- **Demonstrations (through published examples/videos) of phenotyping platforms and integration of molecular data in breeding decisions.**
 - Genetics is Shaping Agriculture and Food | https://www.ted.com/talks/sanushka_naidoo_genetics_is_shaping_agriculture_and_food
 - Breeding Climate-Resilient Crops | <https://www.youtube.com/watch?v=x9lxJcnZMoA>
 - How Technological Change Drives Improvement in Plant Breeding & Agriculture | <https://www.youtube.com/watch?v=bbr1HPNmF8>
 - Genotyping-by-Sequencing (GBS) Explained | <https://www.youtube.com/watch?v=jb7y1USeCBE>
 - What is Marker-Assisted Selection? (CIMMYT) | <https://www.youtube.com/watch?v=0uZcM2E-H2c>

- How Genomic Selection Works in Plant Breeding (CIMMYT) | <https://www.youtube.com/watch?v=pVY6gWgRVYo>
- CRISPR: Gene Editing in Agriculture (Broad Institute) | <https://www.youtube.com/watch?v=jAhjPd4uNFY>
- High-Throughput Plant Phenomics (LemnaTec) | <https://www.youtube.com/watch?v=v0rWb7YwN5o>
- Speed Breeding for Crop Improvement | <https://www.youtube.com/watch?v=c4kCgF5bT2E>

Essential Readings

Plant Breeding: Theory And Practice (1 st edition) (Unit I, II, III, IV)	Neal C Stoskopf, Dwight T Tomes, B. R. Christie, Bertram R Christie	CRC Press (ISBN 9780367298470)
Recent research papers and reviews		

Suggested Readings

Principles of Crop Improvement (2 nd edition) (Unit II)	Norman Simmonds, J. Smartt	Wiley-Blackwell
Genome Mapping in Plants (Unit IV)	Andrew H. Paterson	Academic Press
Principles of Plant Genetics and Breeding (Unit I, II)	George Acquaah	John Wiley & Sons, Ltd.
Marker-Assisted Plant Breeding: Principles and Practices (Unit II)	BD Singh, AK Singh	Springer

SEMESTER 3;S2

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-305**Human Genetics and Genomic Technologies**

Course Objective: *This course provides an advanced understanding of human genetics, integrating classical and complex inheritance patterns, pedigree analysis, modern genomic sequencing technologies, genome editing systems (including CRISPR-Cas platforms), and ethical, legal, and social implications (ELSI) in prenatal, clinical, and population contexts.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-305 Human Genetics and Genomic Technologies	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Foundations of human inheritance and pedigrees	10
II	Genetic mechanisms beyond simple Mendelism	10
III	Human genomics and sequencing technologies	10
IV	Genome editing and ethical, legal, and social issues (ELSI)	15
Tutorial		
Various modalities as given below		15

Course outcomes : On completing 'Human Genetics and Genomic Technologies, the students would have:

- A clear understanding of how classical experiments and human pedigrees reveal chromosomal, molecular, and complex patterns of inheritance, including examples relevant to the Indian population.
- Working knowledge of human genomics, including major DNA sequencing platforms and basic interpretation of sequence quality metrics and variant types in health and disease.
- The ability to compare and apply genome editing tools such as ZFNs, TALENs, and CRISPR systems to modify specific loci in the human genome.
- An integrated understanding of how large-scale genomics projects and genome editing outcomes inform our view of human genetic variation and complex disease.
- Practical skills in evaluating ethical, legal, and social implications of human genomics and genome editing, and in articulating balanced, policy-aware recommendations for their responsible use.

Content (Theory)**45 hours**

- I. **Foundations of human inheritance and pedigrees** (10 hours)
 - Historical foundations: Mendel's laws; Sutton-Boveri chromosomal theory; T.H. Morgan linkage/recombination; DNA as genetic material (Griffith, Avery-MacLeod-McCarty, Hershey-Chase)
 - Pedigree analysis: Standard symbols; constructing/interpreting pedigrees
 - Inheritance patterns: Autosomal dominant/recessive (features, examples including Indian contexts);
 - X-linked recessive/dominant (hemophilia, color blindness); Y-linked; mitochondrial (maternal transmission, heteroplasmy, threshold effects)
- II. **Genetic mechanisms beyond simple Mendelism** (10 hours)
 - Extensions: Incomplete dominance, codominance (e.g., blood groups); complementation; germline mosaicism
 - Penetrance/expressivity: Reduced/age-dependent penetrance; variable expressivity (neurofibromatosis); anticipation (repeat expansions)
 - Advanced mechanisms: Pleiotropy, locus/allelic heterogeneity; genomic imprinting (methylation, control regions);
 - Prader-Willi/Angelman syndromes (deletion/UPD/imprinting defects); epistasis; haploinsufficiency; dominant-negative mutations; synthetic lethality
 - loss of heterozygosity; genetic redundancy; catastrophic rearrangements (chromothripsis, chromoplexy)
- III. **Human genomics and sequencing technologies** (10 hours)
 - Sanger sequencing: Chain-termination, Phred scores, quality assessment
 - Illumina SBS: Library prep, bridge amplification, reversible terminators; 4/2/1 channel chemistries; read-length limits/signal decay; platforms (MiSeq vs NovaSeq)
 - Long-read technologies: Oxford Nanopore (ionic current, error patterns); PacBio/SMRT; applications (SV detection, phasing, isoforms); MinION vs PromethION
 - Emerging: Aviti/polony chemistries; library strategies (TruSeq/Trinity-class, indexing)
 - Human Genome Project: Goals, milestones; post-HGP (variation landscape: SNPs/indels/CNVs); GWAS (common disease-common variant, polygenic scores, limitations); cancer genomics implications
- IV. **Genome editing and ethical, legal, and social issues (ELSI)** (15 hours)
 - Editing platforms: ZFNs/TALENs (architecture, challenges); CRISPR-Cas9 (gRNA, PAM, NHEJ/HDR); base/prime editing; PCSK9 therapeutic example
 - CRISPR biology: crRNA/tracrRNA/spacer/Cas1-2 acquisition; advanced (pegRNA/nickase/RT in prime editing)
 - RNA-targeting: Cas13 advantages (reversibility); collateral cleavage; diagnostics (Sherlock/Cas12-13); dCas13-ADAR fusions (REPAIRv2, specificity)
 - ELSI: Principles (autonomy, beneficence, etc.); confidentiality/privacy; prenatal/reproductive issues; predictive testing/minors; incidental findings; thalassemia screening; surrogacy; cloning (reproductive/therapeutic); eugenics; organ banking; AI risk scores bias

Content (Tutorials)**15 hours****Addressing individual queries on class concepts**

- Clarification of challenging lecture concepts (e.g., locus heterogeneity vs allelic heterogeneity, chromothripsis, read-length constraints, prime editing logic)
- Pedigree problem sets covering multiple inheritance modes, penetrance/expressivity, and risk calculations
- Short technology critiques: Comparing MiSeq vs NovaSeq, MinION vs PromethION, and short-read vs long-read applications · Evaluating sequencing quality using Phred scores
- and simple QC outputs
- Guided reading and discussion of landmark papers and case reports on HGP, GWAS, CRISPR genome editing, imprinting disorders, mitochondrial inheritance, and
- catastrophic genome rearrangements
- Structured ELSI case discussions (small groups) on prenatal diagnosis, predictive testing in minors, incidental findings, cloning, surrogacy, and eugenics
- Written and oral presentations on assignment prompts (therapeutic cloning, soft eugenics, AI-based risk scores)

Discussions on relevant academic resources, videos/ TED talks

- Discussions on landmark discoveries and milestones in human genetics and genomics
<https://www.youtube.com/watch?v=cR5An16ifjQ>
- The Human Genome Project: A Decade Later | Francis Collins |
<https://www.youtube.com/watch?v=Gnt2SJkt83Q>
- CRISPR: Gene editing and beyond | Jennifer Doudna | TED
<https://www.youtube.com/watch?v=TdBAHexVYzc>
- The ethical dilemma of designer babies | Paul Knoepfler | TED
<https://www.youtube.com/watch?v=nOHbn8Q1fBM>
- Ethical dimensions of CRISPR and human genome editing | Various panel discussions
https://www.youtube.com/watch?v=LmMuTCn-N_M
- Sequencing the human genome:
<https://www.youtube.com/watch?v=aRWWldz2YZc>

Key Papers:

- International HapMap Consortium (2005), "A haplotype map of the human genome", Nature 437, 1299–1320: doi:10.1038/nature04226
- 1000 Genomes Project Consortium (2015), "A global reference for human genetic variation", Nature 526, 68–74: doi:10.1038/nature15393
- Lek et al. (2016), Exome Aggregation Consortium (ExAC), "Analysis of protein-coding genetic variation in 60,706 humans", Nature 536, 285–291: doi:10.1038/nature19057
- Karczewski et al. (2020), gnomAD, "The mutational constraint spectrum quantified from variation in 141,456 humans", Nature 581, 434–443: doi:10.1038/s41586-020-2308-7

Essential Reading

1.	Human Molecular Genetics (Unit I, II, III)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II, III, IV)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Reading

1.	Principles of Population Genetics (Unit I, II)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit I, II)	Gillespie JH	Johns Hopkins University Press
3.	Human Evolutionary Genetics (Unit II)	Jobling MA et al.	Garland Science
4.	An Introduction to Population Genetics (Unit I, II, III)	Nielsen R & Slatkin M	Sinauer Associates

SEMESTER 3;S2

GENERAL ELECTIVE

2Y-PG

GE-GEN-310

Genetics in Human Health

Course Objective: This elective paper has been designed to introduce students from other departments to the basic concepts in genetics, with a specific focus on human health. It also aims to provide an overview of the classical and contemporary genetic tools for the improvement of overall life quality. The various aspects of medical genomics focus on tools for genetic analysis of human disorders, the translation of findings for predictive, preventive, personalized, and participatory (P4) medicine, and cellular and animal models of disease for enhanced understanding of disease biology and the development of new therapeutics.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-GEN-310 Genetics in Human Health	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Characteristics of the human genome	3
II	Analysis of genetic disorders	21
III	Clinical cytogenetics and molecular diagnostics	14
IV	Modelling of human genetic disorders and intervention strategies	7
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing ‘Genetics in Human Health’, the students would have:

- A clear understanding of human gene, genome, and chromosome structure, the principles of Mendelian and non-Mendelian inheritance, and the nature of genetic variation in human populations.
- Working knowledge of the molecular basis of human disease, including how different classes of mutation, genotype–phenotype correlations, and gene–environment and epigenetic interactions contribute to rare, common, and cancer-associated disorders.
- The ability to explain and apply major genomic technologies and diagnostic tests, interpret results for clinical use, and recognize key ethical, legal, and social dimensions of genetic testing, counselling, and personalized medicine.
- An integrated understanding of how diverse model organisms are used to mimic human disease mutations, explore conserved gene functions, and perform genetic or drug modifier screens using advanced genetic and genome editing tools.

Content (Theory)

45 hours

I. Characteristics of the human genome (3 hours)

- Introduction of human chromosomes, genes, and genomes.
- An overview of the genetic and molecular basis of syndromes and disorders

II. Analysis of genetic disorders (21 hours)

- Pedigrees: Symbols, construction of pedigrees,
- Inheritance patterns: Dominant, recessive, sex-linked and sex-limited patterns, mitochondrial inheritance.
- Complications to the basic pedigree patterns: Non-penetrance, variable expressivity, late-onset, genomic imprinting, mosaicism and chimerism, X-inactivation, risk assessment.
- Monogenic diseases with established molecular pathology: Cystic fibrosis, Tay-Sachs syndrome
- Polygenic and complex traits/ disorders: Polygenic inheritance, 'Nature -nurture' concept, monozygotic and dizygotic twins. Atherosclerosis, diabetes mellitus
- Genome imprinting syndromes: Prader-Willi and Angelman syndromes
- Repeat expansion disorders/ syndrome: Huntington's disease and fragile X-syndrome
- Genomic instability and cancer: Cell cycle checkpoint and cancer, oncogenes, tumour suppressor genes, DNA repair genes, and genetic instability
- Inborn errors of metabolism and their genetic basis: Phenylketonuria, maple syrup urine syndrome

III. Clinical cytogenetics and molecular diagnostic (14 hours)

- Cytogenetic and molecular diagnostics: Overview of prenatal, neonatal, and adult diagnosis strategies
- Human metaphase chromosomes: types and characteristics
- Human karyotype: banding types, pathology of human chromosomes, common syndromes due to numerical and structural alterations

IV. Modelling of human genetic disorders and intervention strategies (7 hours)

- Modelling of human genetic disorders/ diseases (such as cancer, neurodegenerative disorders) in *Drosophila*, zebrafish, and mouse.
- Screening of genetic modifiers, drug targets, and drugs.
- Management of genetic disorders: Genetic counselling, gene therapies, ethical, legal, and social issues

Content (Tutorial)

15 hours

- Addressing individual queries on class concepts
- Discussing research/ review papers on seminal work in the field of human genetics and medical genetics
- Duong D, Solomon BD. (2025) Artificial intelligence in clinical genetics. *Eur J Hum Genet.* 33(3):281-288. DOI: 10.1038/s41431-024-01782-w
- The Cell Editorial Team. Five decades of genetics and genomics. *Cell.* DOI: 10.1016/j.cell.2024.01.020
- Lamm, Ehud et al. "Before Watson and Crick in 1953 Came Friedrich Miescher in 1869." *Genetics.* 2020;215(2):291-296. DOI: 10.1534/genetics.120.303195
- Mayor, S. "First human chromosome is sequenced." *BMJ.* 1999;319(7223):1453a. DOI: 10.1136/bmj.319.7223.1453a

- Ponting CP. Human genetics seen through an evolutionary lens. *Cell Genom.* 2023;3(5):100323. DOI: 10.1016/j.xgen.2023.100323
- Drets ME, Shaw MW. (1971) Specific banding patterns of human chromosomes. *Proc Natl Acad Sci U S A.* 68(9):2073-2077. DOI: 10.1073/pnas.68.9.2073
- Cohen JS et al. (2022) Genomic answers for children: Dynamic analyses of >1000 pediatric rare disease genomes. *Genet Med.* 24(6):1336-1348. DOI: 10.1016/j.gim.2022.02.007
- Roth TL, Marson A. (2021) Genetic Disease and Therapy. *Annu Rev Pathol.* 16:145-166. DOI: 10.1146/annurev-pathmechdis-012419-032626
- Science Editorial – Modeling Human Disease. *Science.* DOI: 10.1126/science.1227179
- Discussions on relevant TED talks/ academic videos/ digital resources
 - Can we cure genetic diseases by rewriting DNA? By David R. Liu
<https://www.youtube.com/watch?v=ONS9FCY74p0>
 - The human journey-- a genetic odyssey: Spencer Wells at TEDxConnecticutCollege
<https://www.youtube.com/watch?v=xnbxrDGZoBQ>
 - How genetics and environment work together to shape our destiny: Milena Georgieva at TEDxAUBG <https://www.youtube.com/watch?v=gfDikwoAbPk>
 - The World's Rarest Diseases — And How They Impact Everyone | Anna Greka | TED
<https://www.youtube.com/watch?v=n0J1zCHURsQ>
 - The Power of a Genetic Diagnosis | Dr. Vincent Carson | TEDxLancaster
https://www.youtube.com/watch?v=CZ4O_h1wYoo
 - What Is Genetic Counseling? | Jaclyn Haven | TEDxHelena
<https://www.youtube.com/watch?v=7yIW0L9dLCQ>
 - The age of genetic wonder | Juan Enriquez | TEDxCERN
<https://www.youtube.com/watch?v=GPIVILKI5LE>

Essential Readings

1.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Readings

1.	iGenetics A Molecular Approach (Unit I, II)	Russell PJ	Pearson
2.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
3.	Human Genetics (Unit I, II, III)	Ricki Lewis	McGraw Hill
4.	Medical Genetics (Unit III, IV)	Jorde et al.	Elsevier
5.	Genetics and Genomics in Medicine (Unit III, IV)	Cohn et al.	Elsevier
6.	New Clinical Genetics (Unit I, III, IV)	Andrew Read and Dian Donnai	Scion Pub Ltd
7.	Emery's elements of medical genetics and genomics (Unit I, III, IV)	Peter Turnpenny	Elsevier
8.	Evolution of Medical Genetics (Unit II, III)	Peter Harper	CRC Press
9.	Relevant Review and Research Papers (Unit I, II, III, IV)		

SEMESTER 3; S2

RESEARCH PROJECT

2Y-PG

RP-GEN-312-S2

Research Project (Structure 2)

Course Objective:

The objective of this **project work in Semester 3 and Semester 4 of Structure 2** is to provide hands-on experience to the students about handling a research problem. The students will be encouraged to design and carry out a small research project around a topic being investigated in the allotted lab under the supervision of the faculty member. The students are expected to present their objectives and experimental design before initiation of the experimental work. After completion, the students are expected to present their findings as a presentation and report in Semester 4, a continuation of their assigned work.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RP-GEN-312-S2 Research Project	6	0	0	6	B.Sc. in any branch of science	NA

Components of evaluation of research work		
Semester 3		
Preparation and Presentation of Outline of Research Work		
Internal assessment of mentor		
Interim report submission & evaluation		
Presentation and viva-voce		
Semester 4 (continued from Sem 3)		
Internal assessment of mentor		25
Thesis submission & evaluation		75
Presentation and viva-voce		50

Course outcomes : On completing 'Research Project', the students would have:

- Learnt how to inquire
- Acquired the ability to design their own experiments
- Acquired the skill to independently perform experiments
- Understood the importance of critical analysis and use of controls
- Developed the ability to trouble-shoot experiments
- Learnt to analyze data and present the work in written and presentation forma

The student will carry out an independent piece of experimental work in the laboratory of an allotted supervisor. Supervisors for the project work will be based on draw of lots or as decided by the department. The students are expected to make two presentations, and submit a detailed report of the work carried out. The work will also be assessed on a continuing basis.

SEMESTER 4 (2Y-PG)

Structure 2-Coursework+Research

Course Distribution and Overview

Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	2	2 (2DSE+0GE; 1DSE+1GE)	0	1	5
Credits	8	8	0	6	22
Student needs to complete 8+8+0+6 = 22 credits					

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSC-GEN-401	DSC	Population and Quantitative Genetics	4	3	1	0
DSC-GEN-402	DSC	Application of genetic studies in clinical research and plant biotechnology	4	3	1	0
DSE-GEN-403	DSE	Advances in <i>Drosophila</i> genetics	4	3	0	1
DSE-GEN-404	DSE	Biology of Dictyostelium	4	3	0	1
DSE-GEN-405	DSE	Cancer Biology and Genetics	4	3	0	1
DSE-GEN-406	DSE	Molecular plant-microbe interaction	4	3	0	1
DSE-GEN-407	DSE	Yeast genetics	4	3	0	1
GE-GEN-410	GE	Basic Science to Biological Applications (offered only to students of other departments)	4	3	0	1
RP-GEN-412-S2	RP	Research Project	6	0	6	0

1 credit = 15 hours of teaching/ **30 hours** of practical/ **15 hours** of tutorials

DSC-GEN-401

Population and Quantitative Genetics

Course Objective: *This course introduces the theoretical foundations of population genetics, integrating classical models with modern genomic data on human variation. It covers genetic variation, evolutionary forces, Hardy-Weinberg principles, linkage disequilibrium, population structure, human evolutionary and demographic history, and the use of large reference datasets (HapMap, 1000 Genomes, ExAC, gnomAD, Ensembl) for variant interpretation and inference in human genetics.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-401 Population and Quantitative Genetics	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Genetic variation, mutation, and basic population-genetic quantities	10
II	Hardy–Weinberg equilibrium, evolutionary forces, and analytical problems	10
III	Evolutionary genetics, population structure, and human demographic history	10
IV	Human reference panels, databases, and applications in human genetics	15
Practical		
I	Modelling Mendelian inheritance	15
II	Genotyping polymorphisms in human genes using PCR and RFLP	15

Course outcomes : On completing ‘Population and Quantitative Genetics’, the students would have:

- Analyze how evolutionary theory and Mendelian genetics give rise to population-level concepts such as gene pools and allele and genotype frequencies.
- Apply the Hardy–Weinberg principle to predict genotype frequencies from allele frequencies and to assess departures from equilibrium in real datasets.
- Adopt a research mindset to evaluate how key evolutionary forces (mutation, selection, drift, migration, recombination) shape levels and patterns of human genetic diversity.
- Visualize genomic datasets by retrieving and exploring gene and variant information from genome browsers and population genetics databases.
- Use large reference panel datasets to support variant interpretation and to investigate the genetic basis of disease, demography, and human population history.

Content (Theory)**45 hours**

- I. Genetic variation, mutation, and basic population-genetic quantities (10 hours)**
- Historical foundations: Darwinian evolution and Mendelian inheritance; modern synthesis (Fisher); population definition, gene pool, allele/genotype frequencies
 - Types of genetic variation: SNPs, indels, STRs/microsatellites, CNVs, structural variants
 - Allele terminology: reference/alternate, major/minor, risk/protective, ancestral/derived
 - Mutation mechanisms: DNA replication errors, proofreading; per-base/per-division/per-generation rates; mutation load per zygote; higher rates at CpG sites
- II. Hardy–Weinberg equilibrium, evolutionary forces, and analytical problems (10 hours)**
- Allele frequency vs effect size; haplotypes, phasing (statistical/family-based); measuring variation (arrays vs sequencing, tag SNPs, imputation)
 - Linkage disequilibrium (LD): Definitions (D , r^2); factors (distance, recombination hotspots/PRDM9, drift, selection, demography); examples (extended LD in Tibetan high-altitude adaptation, HIF pathway)
 - Hardy–Weinberg principle: Assumptions, derivation (bi-allelic/multiple alleles); genotype from allele frequencies
 - Evolutionary forces: Mutation (forward/back, mutation-selection balance); migration/gene flow (island model); non-random mating (inbreeding, assortative); drift (effective population size, founder/ bottleneck); selection (fitness, coefficients, over/underdominance)
 - Quantitative problems: Allele/ genotype frequency calculations; recessive trait/carrier estimates; HWE testing (chi-square); selection modeling across generations
- III. Evolutionary genetics, population structure, and human demographic history (10 hours)**
- Forces shaping diversity: Mutation, drift, selection, migration, recombination; paternal age effect on de novo mutations; mutation-drift balance
 - Diversity comparisons: Great apes vs humans; effective population size; allele frequency spectra, segregating sites, rare/common variants
 - Population differentiation: F_{st} (definition, values); population-specific rare variants; genetic distance (D_{ij})
 - Structure analysis: PCA (dimension reduction, genotype matrices, plots interpretation, clines/clusters); relation to F_{st}
 - Human history: Out-of-Africa model, continental splits, admixture; case studies (Ashkenazi Jewish bottlenecks/founder events)
 - Race vs ancestry: Biological imprecision of race; variation mostly within groups; limited predictive power for individual genotypes/traits (polygenic scores limitations)
- IV. Human reference panels, databases, and applications in human genetics (15 hours)**

- Ensembl: Genome browser/annotation; gene/transcript counts, regulatory features, variant catalogs, allele frequencies, functional annotations
- HapMap: Aims (haplotype map, tag SNPs); populations; role in GWAS
- 1000 Genomes: Rationale (rare variants, diverse populations); phases (low-coverage/exome/high-coverage); findings (rare variants abundance, structure, structural variants); implications for disease/demography
- ExAC: Exome aggregation; constraint metrics; distinguishing pathogenic/benign variants
- gnomAD: Expansion (exomes + genomes, larger/diverse samples); comparison with ExAC/HapMap/1000 Genomes
- Applications: Rare functional variants in exomes; variant interpretation in clinical/research; medical genetics uses

Content (Practical)

30 hours

I. Modeling Mendelian inheritance.

Objective: To model the inheritance of a simple recessive trait in a population (individuals within class) across five generations. This will help students observe genotype and phenotype frequencies and how small population size affects inheritance patterns due to random factors.

II. Genotyping polymorphisms in human genes using PCR and RFLP.

Objective: To genotype SNP (single nucleotide polymorphisms) in genes with known health implications, such as CYP450 (associated with drug metabolism) and MTHFR (associated with folate metabolism). By genotyping these SNPs, students may investigate the genetic basis of variability in drug response or nutrient processing and relate these to potential health outcomes.

Essential Reading

1.	Principles of Population Genetics (Unit I, II, III, IV)	Hartl DL & Clark AG	Sinauer Associates
2.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science

Suggested Reading

1.	Principles of Population Genetics (Unit I, II, III, IV)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit I, II)	Gillespie JH	Johns Hopkins University Press
3.	Genetics: A Conceptual Approach (Unit I)	Pierce BA	W.H. Freeman
4.	Human Evolutionary Genetics (Unit II, III)	Jobling MA et al.	Garland Science
5.	An Introduction to Population Genetics (Unit I, II, III)	Nielsen R & Slatkin M	Sinauer Associates
6.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science

SEMESTER 4; S2

DISCIPLINE SPECIFIC CORE

2Y-PG

DSC-GEN- 402

Application of genetic studies in clinical research and plant biotechnology

Course Objective: This course delves into the significance of genetic studies in plant biotechnology and clinical research, highlighting their applications in disease diagnosis, crop security, personalized medicine, and gene therapy. It provides an in-depth understanding of various genetic technologies used in healthcare and crop improvement, along with the ethical aspects surrounding their use. Emphasis is placed on how these advancements translate into real-world applications.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-402 Application of genetic studies in clinical research and plant biotechnology	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Applications of Plant Cell and Tissue Culture Technology	11
II	Applications of plant transgenic technology	11
III	Introduction to clinical genetics and genomic medicine	11
IV	Gene therapy and Genome editing in clinical research	12
Practical		
I	Plant tissue culture; regeneration techniques; Agrobacterium mediated genetic transformation of plants.	15
II	Experiments on cfDNA isolation and analysis	15

Course outcomes : On completing 'Application of genetic studies in clinical research and plant biotechnology', the students would have:

- A clear understanding of how plant cell and tissue culture are applied for crop improvement, germplasm preservation, and production of high-value metabolites.
- Working knowledge of plant transgenic technologies for enhancing biotic and abiotic stress resistance, modifying developmental and quality traits, and producing high-value biomolecules, with awareness of public concerns surrounding GM crops.
- The ability to explain core concepts of clinical genetics and genomic medicine, including how human genetic variation underpins disease risk, diagnosis, and prognosis, and how genomic data inform personalized therapies.
- An integrated understanding of gene therapy and genome editing approaches in clinical and agricultural settings, including their mechanisms, therapeutic potential, limitations, and the ethical, legal, and social issues they raise.
- Practical skills in applying genetic and genomic techniques to real-world problems in health and agriculture, interpreting experimental or case-based data, and formulating responsible, evidence-based recommendations for their use in clinical research and plant biotechnology.

Content (Theory)**45 hours****I. Applications of Plant Cell and Tissue Culture**

- Technology- Micropropagation, Virus-free plants, Artificial seeds
- Embryo rescue and in vitro fertilization for hybrid development
- Breakage of seed dormancy
- Haploids, double haploids and triploids
- Somatic hybrids, cybrids and asymmetric hybrids
- In vitro mutants and somaclones for crop improvement
- Production of secondary metabolites; In vitro gene banks and germplasm conservation
- Other applications

II. Applications of plant transgenic technology

- Scope
- Insect resistance - case study of Bt cotton, Bt and other anti-feedant genes
- Resistance management
- Herbicide resistance - study of glyphosate resistance
- Transgenic resistance against viral, bacterial, fungal pathogens and nematode parasites
- Abiotic stress tolerance
- Engineering crops for male sterility, delayed fruit ripening and fatty acid composition
- Nutritional quality and quantity improvement, Metabolic engineering - Golden rice, Hairy roots and secondary products
- Molecular pharming - Production of antibodies, edible vaccines, recombinant proteins, bioplastics, biosteel and other products, Transgenics for cleaning environmental pollutants and production of bio-fuels
- RNAi applications in agriculture
- Other applications
- Global status of GM crops
- Regulations and issues in bio-safety of commercialization and consumption of GM plants and foods.

III. Introduction to clinical genetics and genomic medicine

- Principles of human inheritance, pedigree analysis and genetic risk calculation.
- Chromosomal and single-gene disorders; cytogenetic and molecular diagnostic techniques.
- Genomic technologies in medicine (gene panels, exome/genome sequencing) and variant interpretation.
- Applications in cancer genomics.
- Ethical, legal and social issues; organization of clinical genetic and counseling services.

IV. Gene therapy and Genome editing in clinical research

- Concepts and historical development of human gene therapy; somatic vs germline and in vivo vs ex vivo approaches.
- Gene transfer vectors and delivery systems: viral (AAV, lentiviral, retroviral, adenoviral) and non-viral.
- Genome editing platforms (ZFNs, TALENs, CRISPR-Cas) and design of editing strategies.
- Preclinical models, major clinical applications and selected case studies (e.g. hemoglobinopathies, retinal disease, CAR-T).
- Safety, regulatory and ethical issues in gene therapy and human genome editing; future directions (base/prime editing, epigenome editing).

Content (Practical)**30 hours****I. Experiments on plant transformation**

- i. Shoot tip and nodal bud culture for multiplication

- ii. Plant regeneration (organogenesis)
- iii. Induction of embryogenic callus and plant regeneration in rice
- iv. Agrobacterium-mediated genetic plant transformation

II. Experiments on cfDNA isolation and analysis

- i. Culture of mammalian cell lines and collection of conditioned media for cfDNA.
- ii. Isolation and precipitation of cfDNA from cell culture supernatant.
- iii. Quantification of cfDNA using Qubit dsDNA High Sensitivity assay.
- iv. Fragment length analysis of cfDNA using TapeStation and interpretation of profiles.

Essential Reading

1.	Plant Cell and Tissue Culture (Unit I, II)	Vasil IK & Thorpe TA	Springer
2.	Biotechnology and Crop Improvement Tissue Culture and Transgenic Approaches (Unit I, II)	Nitish Kumar	Taylor & Francis Group
3.	Human Molecular Genetics (Unit III, IV)	Strachan T & Read A	Garland Science
4.	Recent Reviews and research paper (Unit I, II, III, IV)		

Suggested Reading

1.	Principles of Population Genetics (Unit II, III)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit II, III)	Gillespie JH	Johns Hopkins University Press
3.	Genetics: A Conceptual Approach (Unit II, III)	Pierce BA	W.H. Freeman
4.	Human Evolutionary Genetics (Unit II, III)	Jobling MA et al.	Garland Science
5.	An Introduction to Population Genetics (Unit II, III)	Nielsen R & Slatkin M	Sinauer Associates
6.	Human Molecular Genetics (Unit II, III)	Strachan T & Read A	Garland Science
7.	Three strategies of transgenic manipulation for crop improvement (Unit I, II)	Yu H, Yang Q, Fu F, Li W	Front Plant Sci. 13:948518
8.	Applications of Plant Cell and Tissue Culture (Unit I, II)	Bock GR & Marsh J	Wiley

DSE-GEN- 403

Advances in *Drosophila* Genetics

Course Objective: This specialized paper has been designed to provide an advanced understanding of contemporary *Drosophila* genetics and related areas. *Drosophila* has been one of the favored model organisms of geneticists since T. H. Morgan decided to use it in 1910 to investigate the chromosomal theory of inheritance. Thereafter, succeeding generations of “*Drosophilists*” have developed an ever-increasing repertoire of techniques that make *Drosophila* as an indispensable and one of the most tractable multicellular organisms for biomedical research.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-403 Advances in <i>Drosophila</i> Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	<i>Drosophila</i> : An indispensable organism for biomedical research	6
II	Molecular genetics of <i>Drosophila</i> gametogenesis and development	20
III	<i>Drosophila</i> -specific genetic toolkits for functional analysis of genes	10
IV	<i>Drosophila</i> as a model for human genetic disorders, drug screening, aging, and behavioral studies	9
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing ‘Advances in *Drosophila* Genetics’, the students would have:

- Developed a comprehensive understanding of the historical, genetic, and biomedical significance of *Drosophila melanogaster*
- Acquired an integrated understanding of molecular genetic mechanisms underlying development and regulatory processes across life stages.
- Developed the ability to use genetic and molecular approaches to interpret spatial and temporal control of genes.
- Expanded their proficiency in applying advanced genetic tools and genome engineering strategies.
- Understood the capacity of *Drosophila* to model human genetic diseases for therapeutic implications.

Content (theory)

- I. *Drosophila*: An indispensable organism for biomedical research** 6 hours
- An Introduction- Historical perspective, an overview of the life cycle and advantages in genetic analysis, developmental studies, and biomedical research, the nomenclature of genes and mutations, balancer and marker chromosomes and associated common phenotypes, strategies to design genetic crosses, and an overview of *Drosophila*-specific online databases, stock centers, and other resources.
- II. Molecular genetics of *Drosophila* gametogenesis and development** 20 hours
- Axis specification and cellular signalling during oogenesis- *Drosophila* female reproductive system, an overview of the oogenesis and stage identification, selection of potential oocyte, somatic and germ cell derivatives
 - Delta, JAK/STAT, Notch signalling and specification of A/P polar cells and axis determination, ring canals, transportation and localization of transcripts and protein in the oocyte, Gurken signalling and axis determination, border cell migration, cytoplasmic dumping, and oocyte maturation. Analysis of some female sterile mutant lines.
 - Cellular remodelling and differentiation during spermatogenesis-*Drosophila* male reproductive system, mitotic and meiotic cell divisions, spermatogonia, spermatocytes, cyst cell, mitochondrial remodelling, nebenkern, nuclear shaping, actin polymerization, sperm individualization.
 - Overview of embryogenesis, axis formation, and fate map.
 - Genetic hierarchy of development in *Drosophila*- egg polarity genes, the establishment of morphogen gradient, gap genes, pair-rule genes, specification of stripes, regulation of pair-rule gene expression, segment polarity genes, the establishment of segment polarity, homeotic genes, and mutations, antennapedia/bithorax complex, and specification of body organs
 - Larval stages and tissue types, imaginal discs - development and differentiation, axis determination in imaginal discs, regeneration and trans-differentiation, adult morphology, and internal organs
- III. *Drosophila*-specific genetic toolkits for functional analysis of genes** 10 hours
- Genetic tools- Genetic tools for studies on gene expression
 - Generation and analysis of FLP/FRT-mediated somatic clones. MARCM (Mosaic analysis with a repressible cell marker), Generation and analysis of ovoD-mediated germ-line clones
 - Conditional and/or targeted over-expression/ablation of genes/transcripts (e.g. UAS/GAL4/GAL80 system)
 - RNAi-based screening of gene functions, *Drosophila* genome editing by CRISPR-Cas9
 - Stem cells and their maintenance- Somatic and germline stem cells
 - Components and functions of stem cell niches
 - Stemness, Various cellular signalling (i.e. Delta-Notch, JAK-STAT etc.), and maintenance of stemness
 - Differentiation of stem cells and maintenance of organ homeostasis
 - Therapeutic usages of stem cells
 - *Drosophila*- a model system to study immune responses, Induction of immune response, antimicrobial defence, Toll, and Immunodeficiency (IMD) signalling pathways.

IV. *Drosophila* as a model for human genetic disorders, drug screening, aging, and behavioral studies

9 hours

- Modeling of neurodegenerative disorders (i.e. Parkinson's, Huntington's, Alzheimer's diseases etc.), fragile-X syndrome, cancer, mitochondrial dysfunction, cardiac and muscular diseases etc
- Screening and identification of modifier genes, drug targets, and drug molecules
- *Drosophila* in drug screening and toxicological studies, Circadian rhythm in *Drosophila*
- Usages of *Drosophila* in behavioral genetics and aging research

Content (Tutorial)

- **Addressing individual queries on class concepts**
- **Discussing research papers on seminal work in the field, exemplified by the following**
 - Morgan TH. (1910) Sex limited inheritance in *Drosophila*. *Science*. 1910 Jul 22;32(812):120-2. <https://www.science.org/doi/10.1126/science.32.812.120>
 - Lewis EB. (1978) A gene complex controlling segmentation in *Drosophila*. *Nature*. 276(5688):565-70. <https://www.nature.com/articles/276565a0>
 - Konopka RJ, Benzer S. (1971) Clock mutants of *Drosophila melanogaster*. *Proc Natl Acad Sci U S A*. 68(9):2112-6.
 - Victor Atoki et al., (2025) Exploring the versatility of *Drosophila melanogaster* as a model organism in biomedical research: a comprehensive review. *Fly (Austin)*. 19(1):2420453. <https://doi.org/10.1080/19336934.2024.2420453>
 - Brumby AM, Richardson HE. (2005) Using *Drosophila melanogaster* to map human cancer pathways. *Nat Rev Cancer*. 5(8):626-639. <https://www.nature.com/articles/nrc1671>
 - Kimble J, Nüsslein-Volhard C. (2022) The great small organisms of developmental genetics: *Caenorhabditis elegans* and *Drosophila melanogaster*. *Dev Biol*. 485:93-122. <https://doi.org/10.1016/j.ydbio.2022.02.013>
 - Suzuki, DT. (1970) Temperature-sensitive mutations in *Drosophila melanogaster*. *Science*, 170:695-706. <https://www.science.org/doi/10.1126/science.170.3959.695>
 - Hales KG, Korey CA, Larracuenta AM, Roberts DM. (2015) Genetics on the fly: A primer on the *Drosophila* model system. *Genetics*. 201:815 <https://doi.org/10.1534/genetics.115.183392>
 - Bellen HJ, Tong C, Tsuda H. (2010) 100 years of *Drosophila* research and its impact on vertebrate neuroscience: a history lesson for the future. *Nat Rev Neurosci*. 11:514-22. <https://www.nature.com/articles/nrn2839>
- **Discussions on relevant academic resources, videos/ TED talks**
 - Discussions on Nobel Prize-winning discoveries using *Drosophila* as a model organism.
 - The why of the fly | Daniel N. Cox | TEDxGeorgeMasonU <https://www.youtube.com/watch?v=UMeS1gBdzgk>
 - Eric Wieschaus (Princeton) Part 1: Patterning Development in the Embryo <https://www.youtube.com/watch?v=Ncxs21KEj0g>
 - Eric Wieschaus (Princeton) Part 2: Stability of Morphogen Gradients & Movement of Molecules <https://www.youtube.com/watch?v=cpOf5el9Gik>
 - The Fruit Fly as Human Disease Research Tool, Harvard University Educational Video <https://www.youtube.com/watch?v=0cte6rowhao>

- *Drosophila* circadian rhythms, memory and disease models. Faculty of Life Sciences, University of Bristol. <https://www.youtube.com/watch?v=MoS-9HgZCro>
- Drugs, dopamine and *Drosophila* - A fly model for ADHD? | David Anderson | TEDxCaltech https://www.youtube.com/watch?v=L8Bd_p8pbQI
- Eric Wieschaus and Christiane Nüsslein-Volhard: Collaborating to Find Developmental Genes <https://www.youtube.com/watch?v=GmQ9eI1vdGM>

Essential Reading

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
<i>Drosophila</i> Guide (Unit I)	Demerec & Kaufmann	Carnegie Press
<i>D. melanogaster</i> : Practical Uses in Cell and Molecular Biology (Unit I, II, III, IV)	Goldstein & Fyrberg	Academic Press
The making of a fly: The genetics of animal design (Unit III, IV)	Lawrence	Blackwell
<i>Drosophila</i> : Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of <i>Drosophila</i> Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
<i>Drosophila</i> : A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

DSE-GEN- 404

Biology of Dictyostelium

Course Objective: The course is designed to provide some fundamental principles to form an integrated view of various genetic and molecular processes using *Dictyostelium discoideum* as a model system. Tutorials would be in the form of discussions on research and review papers related to each topic, highlighting the advances made in the field.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Biology of Dictyostelium	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	hours
Theory		
I	Introduction to <i>Dictyostelium</i>	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	<i>Dictyostelium</i> in biology and medicine	3
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Biology of Dictyostelium', the students would have:

- Appreciated the classical experiments, emergence of *D. discoideum* as a model organism
- Acquired an in-depth understanding of structural, cellular, biological and regulatory mechanisms of *D. discoideum*
- Developed an understanding of how *D. discoideum* cells respond to nutrient cues using novel and conserved signaling pathways for development and features for cell differentiation.
- Ascertained the relevance of *D. discoideum* as a model system for human diseases

Content (Theory)**45 hours****I. Introduction to *Dictyostelium* (8 hours)**

- An overview; *Dictyostelium discoideum* and its relatives
- History of research on *D. discoideum*
- Classical experiments of Kenneth Raper; Chemotaxis and aggregation
- Evolution and Genome
- Life cycle
- Molecular techniques

II. Cellular organization and initiation of developmental process (9 hours)*Cellular organization and Dynamics*

- Plasma membrane, channels and pumps, macropinocytosis, phagocytosis; Lysosomes; The autophagic vacuoles; Cytoskeletal proteins; Cytokinesis; Cell motility

Initiation of Development

- Transition from growth to development, detection of starvation, events after starvation, Cellular and molecular mechanisms; Factors controlling early development; Sexual development, macrocyst formation

III. Developmental processes and signaling pathways**(23 hours)***Chemotaxis and Aggregation*

- Components of cAMP signal transduction and relay pathway, Secondary messengers and cytoskeletal events; Role of PKA; Developmental regulation of chemotactic components; Role of cGMP and calcium in chemotaxis; Polarity of movement

Cell adhesion and Recognition

- Cell adhesion molecules, cell-cell contact and gene expression; Cell recognition in the sexual development

Signal transduction

- Diffusible molecules
- cAMP signaling, cAMP oscillation and signal relay
- control of aggregation, cell sorting, coordinated cell movement during multicellular morphogenesis
- Prespore gene expression
- Peptide signaling

Cell differentiation and Pattern formation

- Initial cell type choice, cell type specific markers, Cell fate determination
- DIF signaling, DIF-1 and prestalk gene expression
- Prestalk and stalk cell heterogeneity
- Calcium in pattern formation and various models for pattern formation
- Coordinated cell movement and Morphogenesis

IV. *Dictyostelium* in biology and medicine (3 hours)**Content (Tutorial)****15 hours**

- Addressing individual queries on class concepts

- Discussing research papers on seminal work in the field
- Images and videos for learning life cycle, cell differentiation, chemotaxis and other events during growth and developmental
 - A video on *Dictyostelium discoideum*- a slime mold) <https://www.youtube.com/watch?v=5h8WOWEqP6o>
 - John Bonner’s slime mold videos <https://www.youtube.com/watch?v=bkVhLJLG7ug>
 - Coronin and phagocytosis <http://dictybase.org/Multimedia/phagocytosis/gerisch4.avi>
 - cell tracks and a moving slug http://dictybase.org/Multimedia/development/on_agar_cell_tracks.mov
 - Aggregation towards cAMP <http://dictybase.org/Multimedia/development/ax320x.mov>
 - Chemotaxis of large field of cells <http://dictybase.org/Multimedia/development/agg.mpg>
 - Movement of cells during morphogenesis <http://dictybase.org/Multimedia/development/culm.mov>
 - Dictyostelium development http://dictybase.org/Multimedia/development/Dd%20timelapse%206%20days_Kaks_onen.mp4
 - Prestalk cells in slugs <http://dictybase.org/Multimedia/morphogenesis/weijer1.avi>

Essential Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium discoideum</i> : molecular approaches to cell biology. <i>Volume 28 of Methods in Cell Biology</i> (Unit I, II, III)	James A Spudich	Academic Press

Suggested Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium</i> -A model system for cell and developmental biology (Unit I, II, III, IV)	Yasuo Maeda, Kei Inouye and Ikuo Takeuchi (Eds)	Universal Academic Press, Inc. Tokyo Japan
3	Research papers (Unit I, II, III, IV)		

DSE-GEN-405

Cancer Biology and Genetics

Course Objective: *Comprehensive genetic and molecular analysis of tumor progression and advances in technology, have contributed to our understanding of various pathways and molecules. These have been exploited for their therapeutic leading to considerable improvement in patient survival and management for some cancers. In this course, the students get familiar with various aspects of oncology with an emphasis on genetics, biology, diagnosis, prevention and therapy of cancers.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Cancer Biology and Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Epidemiology, etiology, diagnosis and molecular pathology of cancer	10
II	Mechanistic basis of oncogenesis	15
III	Biology of tumour progression	10
IV	Advances in cancer diagnostics and therapy	10
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Cancer Biology and Genetics’, the students would have:

- Developed a clear understanding of how cancers originate and are classified, and how various factors contribute to disease development and diagnosis.
- Gained insight into the biological mechanisms and genetic basis of cancer initiation, uncontrolled cell growth and tumor formation.
- Understood how tumors progress and spread, and how interactions with surrounding tissues and metabolism influence disease outcome.
- Appreciated the role of the immune system in controlling cancer and the strategies tumors use to escape immune recognition.
- Acquired an overview of modern approaches to cancer diagnosis and treatment, and how molecular knowledge has shaped current and emerging therapeutic strategies.

Content (Theory)**45 hours**

- I. Etiology and molecular pathology of cancer (10 hours)**
 - Pathology of tumor/cancer tissues
 - Classification of tumor/cancers; major cancer types
 - Approaches for cancer diagnostics and tumor markers
 - Molecular pathology -Molecular and diagnostic markers
 - Influence of environment and lifestyle changes
 - Broad overview of environmental, chemical, physical, infectious, genetic, and lifestyle risk factors; concept of multistep carcinogenesis and latency.
 - Cancer and Aging
- II. Mechanistic basis of oncogenesis (15 hours)**
 - Classical and new hallmarks of cellular transformation
 - Chromosomal rearrangements, Mutations, Aneuploidy
 - Genetic basis of oncogenesis – historical theories, discovery of tumor suppressors and oncogenes
 - Multistage tumorigenesis and tumor evolution
 - Hereditary and familial cancers
 - Viral theory of carcinogenesis- discovery of tumor suppressors and oncogenes
 - DNA repair defects and mutator hypothesis - Loss of heterozygosity analysis, allelotyping, microsatellite instability
- III. Biology of tumor progression (10 hours)**
 - Signalling pathways of cancer
 - Cancer progression: Metastatic cascade, Angiogenesis, Epithelial to mesenchymal transformation
 - Tumor microenvironment – Warburg effect, immune and other cells, inflammation and hypoxia
 - Role of immune system in preventing tumor growth
 - Acquired escape mechanisms against immune surveillance
 - Tumor antigens and T cell activation
- IV. Advances in cancer diagnostics and therapy (10 hours)**
 - Mutational signatures; driver and passenger mutations; heterogeneity
 - Cancer treatment modalities and assessment of prognosis
 - Targeted therapy and synthetic lethality
 - Mechanisms of resistance
 - Examples of cancer treatment and their evolution based on molecular and technological advances.

Content (Tutorials)**15 hours**

The tutorials in this course are designed to encourage the students to take a holistic approach to learning about cancer by understanding the role of the researcher, oncologist and the patient.

- Discussions on books such as:
 - a. Rebel Cell: Cancer, Evolution, and the New Science of Life's Oldest Betrayal by Kat Arney (Author) ISBN-13978-1950665303
 - b. The Emperor of All Maladies : A Biography of Cancer (Winner of the Pulitzer Prize for Non-fiction 2011) Edition2011 by Siddharth Mukherjee ISBN-13978-0007250929
 - c. The Immortal Life of Henrietta Lacks by Rebecca Skloot ISBN-13978-0330533447

- Discussions on original research articles on model systems (in vitro, in vivo and other organisms) for studying cancers, aging and its prevalence in the animal and plant kingdom
- Discussion on Nobel prize winning lectures and notes as available on nobelprize.org. Some of the noteworthy ones being
 - a. The Nobel Prize in Physiology or Medicine 1966 to Peyton Rous "for his discovery of tumour-inducing viruses" and Charles Brenton Huggins "for his discoveries concerning hormonal treatment of prostatic cancer"
 - b. The Nobel Prize in Physiology or Medicine 1975 to Dulbecco, Temin and Baltimore on mechanisms of tumor viruses
 - c. J. Michael Bishop - Nobel Prize lecture on 8 December 1989
<https://youtu.be/CDv77rmzKR4?si=bMvhS4RodpZMws3m>
 - d. James P. Allison delivered the lecture "Immune Checkpoint Blockade in Cancer Therapy: New insights, opportunities, and prospects for cures"
<https://www.youtube.com/live/slHiM-PBTJ8?si=QMPHUGtAYXI7JqXH>
- Discussion on individual contribution of 2019 The Nobel Prize in Physiology or Medicine on The von Hippel-Lindau Tumor Suppressor Gene: Insights into Oxygen Sensing and Cancer by William G. Kaelin Jr., Sir Peter J. Ratcliffe, and Gregg L. Semenza
- Discussions on seminal papers as well as current research papers related to the theoretical concepts

Essential reading:

1. The Biology of Cancer (Unit I, II, III, IV)	Robert A. Weinberg (Ed.)	Garland Sciences
2. Hallmarks of cancer (Unit II, III)	Hanahan and Weinberg	Cell, Cell Press 2011 https://doi.org/10.1016/j.cell.2011.02.013
3. The hallmarks of cancer (Unit II, III, IV)	Hanahan and Weinberg	Cell. Cell Press 2000 https://doi.org/10.1016/S0092-8674(00)81683-9

Suggested reading:

1. The Molecular Biology of Cancer (Unit II)	Pelengaris S, Khan M (Eds.)	Blackwell Publishing, Oxford
2. The Genetic Basis of Human Cancer (Unit II, III)	Vogelstein & Kinzler	McGraw-Hill
3. Review and research articles as suggested in class (Unit I, II, III, IV)		

DSE-GEN-406

Molecular Plant-Microbe Interaction

Course Objective:

Pathogenic microbes are a global threat not only to human health but also to food production and quality. With the ever-increasing demand to improve agricultural yields and keep up with global food demand, this area of host–microbe interaction is becoming increasingly important for sustainable agriculture. The interactions between microbes and plants provide fascinating examples of biological communication. The course is designed to understand the molecular intricacies underlying host–pathogen relationships and to apply these insights to develop sustainable strategies for enhanced disease resistance in crops.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-406 Molecular Plant-Microbe Interaction	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Introduction and Experimental methods used in plant pathology and biocontrol	10
II	Microbial pathogenicity: molecular basis and evolution	15
III	Plant defence mechanisms: Molecular interactions and cross-talks	15
IV	Deploying Disease resistance strategies for sustainable agriculture	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Molecular plant-microbe interactions’, the students would have:

- Developed a foundational understanding of plant–microbe interactions and their importance for plant health and sustainable crop production.
- Gained insight into the molecular basis and evolution of microbial pathogenicity
- Understood the key components of plant defence systems and the complex molecular cross-talk involved in immunity.
- Learned how plants distinguish between pathogenic and beneficial microbes at the molecular and cellular levels.
- Acquired an appreciation of emerging disease resistance strategies and biotechnological approaches for sustainable agriculture.

Content (Theory)**45 hours**

- I. **Introduction to plant-microbe interaction (10 hours)**
 - A historical perspective on the significance of plant health and current challenges to sustainable crop production, including beneficial microbes.
 - Introduction to central concepts underlying host-microbe interactions- pathogenic and symbiotic interactions
 - Genomic tools, molecular and cellular genetics, imaging for bacteria, fungi and oomycetes
- II. **Microbial pathogenicity: Molecular basis and evolution (15 hours)**
 - Pathogenesis concepts and definition, Molecular determinants of bacterial and fungal pathogenicity: effectors, elicitors, plant cell wall-degrading enzymes, host-specific toxins, host non-specific toxins, small RNA.
 - Beneficial microbes
- III. **Plant defence mechanisms: Molecular interactions and cross-talks (15 hours)**
 - Non-host resistance, Plant innate immunity, Pre-formed inhibitors of pathogen invasion
 - R genes (quantitative and monogenic resistance)
 - Guards and Decoys
 - Role of mobile small RNAs
 - Systemic acquired resistance.
 - How do plants differentiate good microbes from the bad guys
- IV. **Emerging Disease resistance strategies for sustainable agriculture (5 hours)**
 - Translational research advances and potentials:
 - Application of biotechnological tools, including genomics (NGT), transcriptomics, molecular genetics, gene editing (e.g. CRISPR-Cas9), and gene silencing (PTGS, HIGS, etc.)
 - Application of microbes for improving plant health

Content (Tutorials)**15 hours**

1. Addressing individual queries on class concepts
2. Discussing relevant video content exemplified by :
 - How plant immune systems protect them from disease by Prof Jonathan DG Jones, The Sainsbury Lab
<https://www.youtube.com/watch?v=uVd1CYZDhnU>
 - Understanding the amazing ways plants defend themselves through videos by Prof Sheng-Yang-He
[Sheng-Yang He \(Michigan State U. and HHMI\) 1: Introduction to Plant-Pathogen Interactions - YouTube](#)
[Sheng-Yang He \(Michigan State U. and HHMI\) 2: The effect of climate on plant disease](#)
 - Strategies for resistance to plant virus diseases

<https://www.youtube.com/watch?v=B82UmkOAgd8>

Discussing the related review articles:

- The plant immune system: From discovery to deployment (2024) Cell, Volume 187, Issue 9, 2095 - 2116
- Pathogen perception and signalling in plant immunity,(2024) Plant cell 36: 1465-1481
- Pattern-recognition receptors are required for NLR-mediated plant immunity (2021) Nature Plants: 7, pages 382–383
- Receptor networks underpin plant immunity (2018) Science; 360: 6395, pp. 1300-1301

DOI: 10.1126/science.aat2623

- Plant-Pathogen Effectors: Cellular Probes Interfering with Plant Defenses in Spatial and Temporal Manners (Annu Rev Phytopathol, 2016) 54:419-441.
- Action Mechanisms of Effectors in Plant-Pathogen Interaction. Int. J. Mol. Sci. 2022, 23, 6758. <https://doi.org/10.3390/ijms23126758>
- Susceptibility genes 101: How to be a good host Annual Review of Phytopathology (2014) 52:551–81.

Essential Readings

Plant Pathology (Unit I, II, III, IV)	Agrios GN	Academic Press
Recent Reviews and research paper		

Suggested Readings

Molecular Plant pathology (Unit I, II, III, IV)	Dickinson M	BIOS Scientific Press
Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions (Unit I, II, III, IV)	Jeng-Sheng HT	Kluwer Academic Publ.

SEMESTER 4; S2

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-407

Yeast Genetics

Course Objective: *The course is designed to provide some fundamental principles on which to form an integrated view of various genetic and molecular processes using yeast as a model system. Tutorials would be in the form of discussion based on primary literature available related to each topic, highlighting the advances in each field.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-407 Yeast Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	The Yeast Genome and Functional Genomics	10
II	Mitochondrial Biology and Nuclear–Mitochondrial Communication	15
III	Nutrient Sensing, Signaling, and Yeast Longevity	15
IV	Protein-Based Inheritance and Pathogenicity in Yeasts	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing 'Yeast Genetics', the students would have:

- Developed a clear understanding of the yeast genome as a model system and its significance in modern genetics and cell biology.
- Gained insight into genome-wide approaches of the post-genomic era for studying gene function and cellular organization.
- Understood the principles of mitochondrial structure and dynamics and their regulation within the cell.
- Learned how mitochondrial function and gene expression are coordinated with the nuclear genome.
- Acquired the ability to integrate genomic and mitochondrial processes to explain cellular adaptation and signaling.

Content (Theory)**45 hours****I. The Yeast Genome and Functional Genomics (10 hours)**

- Structure and organization of the yeast genome
- overview of life processes
- life with 6000 genes
- Advances in the post-genomic era :genome-wide microarray analysis, proteomics, and global protein localization studies.
- Functional genomics approaches : synthetic gene array analysis and large-scale genome engineering projects including SC2.0.

II. Mitochondrial Biology and Nuclear–Mitochondrial Communication (15 hours)

- Mitochondrial physiology in yeast
- Organelle dynamics, fusion and fission processes.
- Regulation of mitochondrial function by the nuclear genome
- mechanisms of mitochondrial gene expression
- Retrograde signaling pathways
- coordination between mitochondrial activity and nuclear gene expression.

III. Nutrient Sensing, Signaling, and Yeast Longevity (15 hours)

- Concepts of chronological and replicative life span in yeast
- Effects of environmental and nutritional cues, including calorie restriction and amino acid starvation, on cellular longevity
- Nutrient-dependent signaling pathways such as TOR signaling
- transcriptional regulation mediated by GCN4.

IV. Protein-Based Inheritance and Pathogenicity in Yeasts

- Prions in yeast as epigenetic elements,
- inheritance patterns, propagation mechanisms, de novo formation, structural features, and biological consequences of prions
- Overview of pathogenic yeasts and associated diseases, with an introduction to *Candida albicans*.
- Comparative analysis of *Saccharomyces cerevisiae* and *Candida albicans* focusing on mating types, mitochondrial physiology, and carbon utilization strategies.

Content (Tutorials)**15 hours**

- Addressing individual queries on class concepts
- Discussing research papers on the power of budding yeast: The Yeast Genome and Functional Genomics
- The Power of Yeast <https://doi.org/10.1002/yea.70009>
- Nobel Yeast Research <https://doi.org/10.1093/femsyr/fow094>
- The art and design of genetic screens: yeast <https://doi.org/10.1038/35088500>
- Discussing research papers on Mitochondrial Biology and Nuclear–Mitochondrial Communication
- The Warburg and Crabtree effects: On the origin of cancer cell energy metabolism and of yeast glucose repression <https://doi.org/10.1016/j.bbabi.2010.08.010>
- Nucleus to Mitochondria: Lost in Transcription, Found in Translation <https://doi.org/10.1016/j.devcel.2016.06.003>
- Synchronized mitochondrial and cytosolic translation programs <https://doi.org/10.1038/nature18015>
- Discussing research papers on Nutrient Sensing, Signaling, and Yeast Longevity

- The power of yeast genetics applied to the powerhouse of the cell
<https://doi.org/10.1016/j.tem.2014.12.002>
- Replicative and Chronological Aging in *Saccharomyces cerevisiae*
<http://dx.doi.org/10.1016/j.cmet.2012.06.002>
- Mitochondrial quality control during inheritance is associated with lifespan and mother–daughter age asymmetry in budding yeast <https://doi.org/10.1111/j.1474-9726.2011.00731.x>
- Mitochondrial anchorage and fusion contribute to mitochondrial inheritance and quality control in the budding yeast *Saccharomyces cerevisiae* <https://doi.org/10.1091/mbc.E15-07-0455>
- Discussing research papers on Protein-Based Inheritance and Pathogenicity in Yeasts
- Prions in Yeast <https://doi.org/10.1534/genetics.111.137760>
- Yeast Prions: Structure, Biology, and Prion-Handling Systems
<https://doi.org/10.1128/membr.00041-14>

Essential Readings

- | | | | |
|----|--|---------------------------|-------------------------|
| 1. | Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit I, II, III, IV) | Guthrie C & Fink GR(Eds.) | Elsevier Academic Press |
|----|--|---------------------------|-------------------------|

Suggested Readings

- | | | | |
|----|---|----------------------------------|-------------|
| 1. | Getting started with yeast, Methods Enzymol. Vol. 350, pp. 3-41 (2002) (Unit I, II) | Sherman F | |
| 2. | Yeast Research: A Historical Overview (Unit I, II, IV) | James A. Barnett & Linda Barnett | A S M Press |

GE-GEN-410

Basic Science to Biological Application

Course Objective:

The root of fascinating technological advances in biological science is in the basic science research with no inkling of future possibilities. Whether serendipitous or planned, this concept of blue sky research has contributed tremendously to advancement in science. This general elective aims to illuminate the students with the excitement of doing basic science research particularly in the light of their subsequent usage in biological application.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-410 Basic Science to Biological Application	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Discoveries related to Nucleic acids	6
II	Discoveries related to Gene regulation	11
III	Discoveries related to cell biology	16
IV	Discoveries related to Protein Science	7
Tutorials		
Various modalities as given below		15

Course outcomes : On completing 'Basic Science to Biological Applications', the students would have:

- Developed an understanding of key discoveries in nucleic acid biology and how they transformed genome manipulation and functional analysis.
- Gained insight into major breakthroughs in gene regulation and molecular tools that enable controlled gene expression and interaction studies.
- Understood landmark discoveries in cell biology that led to modern plant transformation and biotechnological applications.
- Learned how advances in protein science have shaped structure prediction and functional analysis.
- Appreciated how foundational biological discoveries translate into real-world applications such as drug discovery therapeutic protein production and regenerative biology.

Content (Theory)**45 hours****I. Discoveries related to Nucleic acids (6 hours)**

- RNA interference
- Genome editing: CRISPER TALEN
- Transposon discovery to applications

II. Discoveries related to Gene regulation (11 hours)

- The regulatable promoter
- Yeast 2-hybrids
- Phage display (antibody) Gibson assembly
- Gateway cloning
- Yamanaka factors to stem cell reprogramming

III. Discoveries related to cell biology (16 hours)

- *Agrobacterium tumefaciens* mediated crown gal formation to plant transformation
- *Agrobacterium rhizogenes* mediated hairy roots to secondary metabolite production

IV. Discoveries related to Protein Science (7 hours)

- Crystallography to Alpha fold
- examples in Drug discovery applications
- Secretion pathway discovery to Insulin production

Content (Tutorial)**15 hours**

- **Addressing individual queries on class concepts**
- **Discussing research papers on discoveries related to Nucleic acids**
 - RNA Interference: Big Applause for Silencing in Stockholm
<https://doi.org/10.1016/j.cell.2006.12.001>
 - Introduction of a Chimeric Chalcone Synthase Gene into Petunia Results in Reversible Co-Suppression of Homologous Genes in trans
<https://doi.org/10.1105/tpc.2.4.279>
 - Flavonoid genes in petunia: addition of a limited number of gene copies may lead to a suppression of gene expression <https://doi.org/10.1105/tpc.2.4.291>
 - The new frontier of genome engineering with CRISPR-Cas9
<https://doi.org/10.1126/science.1258096>
- **Discussing research papers on discoveries related to Gene regulation**
 - Yeast Gal4: a transcriptional paradigm revisited
<https://doi.org/10.1038/sj.embor.7400679>
 - The evolution of the GALactose utilization pathway in budding yeasts
<https://doi.org/10.1016/j.tig.2021.08.013>
 - Studies on the positive regulatory gene, GAL4, in regulation of galactose catabolic enzymes in *Saccharomyces cerevisiae* <https://doi.org/10.1007%2F2F00268616>
 - GAL4 system in drosophila: A fly geneticist's swiss army knife
<https://doi.org/10.1002%2Fgene.10150>
 - Separation of DNA Binding from the Transcription-Activating Function of a Eukaryotic Regulatory Protein <https://doi.org/10.1126/science.3080805>

- **Discussing research papers on discoveries related to cell biology**
 - Beyond My Wildest Expectations (A review by Eugene Nester regarding discovery of plant transformation) <https://doi.org/10.1146/annurev-micro-091313-103703>
 - Agrobacterium tumefaciens: From crown gall tumors to genetic transformation <https://doi.org/10.1016/j.pmpp.2011.06.004>
 - Agrobacterium tumefaciens: a Transformative Agent for Fundamental Insights into Host-Microbe Interactions, Genome Biology, Chemical Signaling, and Cell Biology <https://doi.org/10.1128/jb.00005-23>
- Discussing relevant video and popular blog content exemplified by
 - The CRISPR Apostle: Rodolphe Barrangou <https://www.youtube.com/watch?v=7qS2fjeVzsk>
 - Nobel winners Doudna, Charpentier discover how CRISPR Cas9 gene editing works <https://youtu.be/cuHD7jCY8X4>
 - Tinkering with Nature’s Tools: The CRISPR Pioneer Feng Zhang <https://youtu.be/x4o6IINr7pc>
 - Scientist Stories: Shinya Yamanaka, Cell reprogramming and Pioneering Induced Pluripotent Stem Cells <https://youtu.be/c5DxfekDGk>
- Discussing relevant popular blog/content online exemplified by
 - Biographical Overview | Barbara McClintock - Profiles in Science <https://profiles.nlm.nih.gov/spotlight/l/>
 - Barbara McClintock and the Discovery of Jumping Genes (Transposons) <https://www.nature.com/scitable/topicpage/barbara-mcclintock-and-the-discovery-of-jumping-34083/>
 - Stem Cell Reprograming <https://iscrm.uw.edu/what-is-cell-reprogramming/>

Essential Reading

1.	The Gene: An Intimate History (Unit I, II, III, IV)	Siddhartha Mukherjee	Penguin Random House India
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Suggested Readings

1.	The Gene: An Intimate History (Unit I, II, III, IV)	Siddhartha Mukherjee	Penguin Random House India
2.	The Song of the Cell: An Exploration of Medicine and the New Human (Unit III)	Siddhartha Mukherjee	Bodley Head
3.	The Double Helix (Unit 1, II, IV)	James D. Watson	Atheneum Publishers in New York
4.	Gene Machine (Unit II, IV)	Venki Ramakrishnan	Basic Books

SEMESTER 4; S2

RESEARCH PROJECT

2Y-PG

RP-GEN-412-S2

Research Project (Structure 2)

Course Objective:

The objective of this **project work in Semester 3 and Semester 4 of Structure 2** is to provide hands-on experience to the students about handling a research problem. The students will be encouraged to design and carry out a small research project around a topic being investigated in the allotted lab under the supervision of the faculty member. The students are expected to present their objectives and experimental design before initiation of the experimental work. After completion, the students are expected to present their findings as a presentation and report in Semester 4, a continuation of their assigned work.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RP-GEN-312-S2 Research Project	6	0	0	6	B.Sc. in any branch of science	NA

Components of evaluation of research work	
Semester 3	
Preparation and Presentation of Outline of Research Work	
Internal assessment of mentor	
Interim report submission & evaluation	
Presentation and viva-voce	
Semester 4 (continued from Sem 3)	
Internal assessment of mentor	
Thesis submission & evaluation	
Presentation and viva-voce	

Course outcomes : On completing 'Research Project', the students would have:

- Learnt how to inquire
- Acquired the ability to design their own experiments
- Acquired the skill to independently perform experiments
- Understood the importance of critical analysis and use of controls
- Developed the ability to trouble-shoot experiments
- Learnt to analyze data and present the work in written and presentation format

The student will carry out an independent piece of experimental work in the laboratory of an allotted supervisor. Supervisors for the project work will be based on draw of lots or as decided by the department. The students are expected to make two presentations, and submit a detailed report of the work carried out. The work will also be assessed on a continuing basis.

**TWO YEAR
MASTERS IN GENETICS
POST GRADUATE PROGRAMME
Semester 3 & 4 (**Structure 3**)**



**DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS**

MSC GENETICS – TWO YEAR DEGREE PROGRAM

Course Structure and Credits Overview

Students enter into this program after three years of graduation from any discipline in Science through an entrance exam only. **After completion of their one year (Semester 1 & 2), which is exactly the same for all 2 year PG students-** they will enter into three possible Structures in their second year (Semester 3 & 4) as prescribed by the University.

Their entry into these Structures will be in consultation with the Department based on available infrastructure, facilities and teaching faculty. These structures have been prescribed based on the distribution of core (C), elective (E), 2 credit course skill based course (2c/SBC) and research project (R) component. Our department has been keeping experimental training in the forefront of our Masters programs enabling our students to seek research as a career option. Therefore, we have incorporated our experimental training based on the theory being taught as a Core subject wherever permissible. The credits under each course type are divided into Theory/Lecture (L), Practical (P) and Tutorial (T) as per the norms shared by the University. The division is shown along with the course content of every semester.

1 credit = 15 hours of teaching/30 hours of practical/15 hours of tutorials

Distribution Of Course Type Credits Under Each Structure When The Students Exit Msc Genetics (2Y) Program

	Core	Elective	2 credit courses	Research project	Credits earned at exit of MSc-2Y PG
Structure 1	40	40	8	0	88
Structure 2	40	32	4	12	88
Structure 3	28	24	10	26	88

Overview Of The Structures Available To Msc. Genetics (2Y Program) – Semester-Wise Distribution

	Semester 1 (same courses for all)				Semester 2 (same courses for all)				Semester 3				Semester 4				Total credits
	C	E	2c	R	C	E	2c	R	C	E	2c	R	C	E	2c	R	
Structure 1	12	8	2	0	12	8	2	0	8	12	2	0	8	12	2	0	88
Structure 2	12	8	2	0	12	8	2	0	8	8	0	6	8	8	0	6	88
Structure 3	12	8	2	0	12	8	2	0	4	4	4	10	0	4	2	16	88

C: Core; E: Elective (Discipline specific/Open); 2c (2 credit core courses); R: Research project

Note regarding Electives:

Elective courses are either Discipline specific elective (DSE, offered by the department of genetics) or general elective (GE, offered by other departments) Students can either opt for all DSE offered by its own department or opt for ANY ONE of the GE by other department in addition to other DSE(s) to complete their quota of electives in a particular semester.

Two year MSc Genetics, 2Y-PG Structure 3 (Research)

Course Code	Type/credit	Title	
Semester 1			
DSC-GEN-101	DSC/4	Biological Processes and Patterns of Inheritance	Compulsory
DSC-GEN-102	DSC/4	Genes, Genome and Chromosomes	
DSC-GEN-103	DSC/4	Experiential learning in Genetics- I	
DSE-GEN-104	DSE/4	Molecular Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-105	DSE/4	Cell Biology	
DSE-GEN-106	DSE/4	Enzymology and Metabolism	
GE-GEN-110	GE/4	Genetics in Crop Improvement (offered only to students of other departments)	
SBC-GEN-111	SBC/2	Statistical Analysis in Biology	
Semester 2			
DSC-GEN-201	DSC/4	Regulation of Gene Expression	Compulsory
DSC-GEN-202	DSC/4	Recombinant DNA Technology	
DSC-GEN-203	DSC/4	Experiential learning in Genetics- II	
DSE-GEN-204	DSE/4	Developmental Biology	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
DSE-GEN-205	DSE/4	Immunology and Immunogenetics	
DSE-GEN-206	DSE/4	Mitochondrial Biology and Connection to Cell Physiology	
GE-GEN-210	GE/4	Genetics in Everyday Life: From DNA to Society (offered only to students of other departments)	
SBC-GEN-211	2CC/2	Microscopy and Imaging	
Semester 3			
DSC-GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
DSE-GEN-303	DSE/4	Genetics of Microorganisms	Option of any 1 DSE or 1 GE (GE offered by other departments)
DSE-GEN-304	DSE/4	Plant Genetics and Breeding	
DSE-GEN-305	DSE/4	Human Genetics and Genomic Technologies	
GE-GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
SBC-GEN-311	2CC/2	Advanced Research Methodology	Compulsory
TR-GEN-312	2CC/2	Research Laboratory Practices & Instrumentation	Compulsory
RP-GEN-313-S3	RP/10	Research Project	Compulsory
Semester 4			
DSE-GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 1 DSE or 1 GE (GE offered by other departments)
DSE-GEN-404	DSE/4	Biology of Dictyostelium	
DSE-GEN-405	DSE/4	Cancer Biology and Genetics	
DSE-GEN-406	DSE/4	Genetics of plant-microbe interaction	
DSE-GEN-407	DSE/4	Yeast genetics	
GE-GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
SBC-GEN-411	2CC/2	Scientific Writing and Presentation	Compulsory
RP-GEN-413-S3	RP/16	Research Project	Compulsory

SEMESTER 3 (2Y-PG) Structure 3- Research

Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	1	1 (2DSE+0GE; 1DSE+1GE)	1	1	5
Credits	4	4	4	10	22
Student needs to complete 4+4+4+10 = 22 credits					

Course Distribution and Overview

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSC-GEN-301	DSC	Principles of Genetic analysis	4	3	1	0
DSE-GEN-303	DSE	Genetics of microorganisms	4	3	0	1
DSE-GEN-304	DSE	Plant Genetics & Breeding	4	3	0	1
DSE-GEN-305	DSE	Human Genetics	4	3	0	1
GE-GEN-310	GE	Genetics in Human Health	4	3	0	1
SBC-GEN-311	2CC/2	Research Methodology	2	1	1	0
TR-GEN-312	2CC/2	Research Laboratory Practices & Instrumentation	2	1	1	0
RP-GEN-313-S3	RP/10	Research Project	10	0	10	0

1 credit = 15 hours of teaching/ 30 hours of practical/ 15 hours of tutorials

DSC-GEN-301

Principles of Genetic Analysis

Course Objective: The paper on Genetic Analysis builds upon the foundation laid by Biological Processes and Inheritance Patterns, taught in Semester I, or equivalent courses from undergraduate programs in the four-year curriculum. Unit 1 is structured to reinforce the fundamental concepts of genetic analysis introduced earlier, with a strong emphasis on self-reading and assignments to deepen understanding. Recognizing the diverse methodologies available for genetic analysis in different organisms the subsequent units 2 and 3 focus on outlining essential concepts rather than detailing specific analytical instances. These topics will be enriched with case studies, and the mentor will select the specific examples most relevant for discussion. Unit 4 is introductory in nature and will be covered in details in other papers.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-301 Principles of Genetic Analysis	4	3	0	1	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Recap of key concepts	8
II	Power of genetic analysis	20
III	Of maps and distances	10
IV	Genes and Populations	7
Practical		
I	Studying inheritance in bacteria through conjugation	15
II	Studying inheritance in eukaryotes using appropriate model system	15

Course outcomes : On completing 'Principles of genetic analysis', the students would have:

- Developed a strong conceptual foundation in genetic variation and inheritance patterns
- Gained an understanding of how genetic analysis is employed in different model systems to reveal gene function and biological pathways
- Learned how mutations are generated, identified and analyzed to connect phenotypes with underlying genes.
- Understood the principles and purpose of genetic and physical mapping in locating genes and interpreting recombination.
- Acquired insight into the genetic analysis of populations and complex traits using natural variation and genome-wide approaches.

Content (Theory)**45 hours****I. Recap of key concepts (8 hours)**

- Variations : key to genetic analysis
- Cellular and Molecular basis of inheritance patterns
- Epistasis and Genetic pathways
- Probability and statistics in genetic analysis
- Societal impact of genetics

II. Power of genetic analysis (20 hours)

- Pros and cons of different systems: e.g. Viruses, bacteria, yeast, *C. elegans*, *Drosophila*, *Arabidopsis*, mouse, humans
- Mutations: Generating, finding and classifying mutants
- Assigning mutants to genes - complementation test
- Phenotype to DNA sequence – Forward Genetics
- Cloned genes to mutant phenotype – Reverse Genetics
- Genome-wide mutant screens

III. Of maps and distances (10 hours)

- The classical mapping strategy: Three-point test cross and fine structure mapping of genes- what do they teach us?
- Temporal and recombination maps
- Physical versus Genetic maps
- Mapping genes to chromosomes
- Why create maps ?

IV. Genes and Populations (7 hours)

- Genome wide associations
- Genetic analysis of complex traits
- Genetic analysis using natural variations

Content (Practical)**30 hours****I. Studying inheritance in bacteria through conjugation**

- Setting up crosses bacterial crosses using differing recipient strains of *E. coli*
- Recovery of ex-conjugates using media designed to screen for respective markers present in the donor
- Confirmation experiments of successful conjugation using F+ and F – strains of *E. coli*

II. Studying inheritance in eukaryotes using appropriate model system

- Students will be given experiential training in analyzing segregating population of *Arabidopsis*/ seeds to understand basic principal of independent assortment and segregation
- Statistical analysis of generated data (from above) using chi square test

Essential Reading

1.	Genetics: Analysis: Genes, genomes and Networks (Unit I, II, III, IV)	Meneely P	2 nd Edition Oxford University Press
2.	Introduction to Genetic Analysis (Unit I, II, III, IV)	Griffiths A JF et al	12 th Edition Macmillan International Higher Education

Suggested Reading

1.	Genetics: Principles and Analysis (Unit I, II, III, IV)	Hartl DL and Jones EW	Jones and Bartlett Publishers
2.	Concepts of Genetics (Unit I, II, III, IV)	Klug W, Cummings MR, Spencer CA, Palladino MA	Pearson Publishing
3.	Genetics of Bacteria (Unit II)	Srivastava S	Springer Nature
4.	Research papers as suggested by the teacher (Unit I, II, III, IV)		

SEMESTER 3; S3

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-303

Genetics of Microorganisms

Course Objective: *Microorganisms have occupied a significant space in the field of not just genetics but also immunology and biochemistry. Combining the structural simplicity with the unifying genetic basis, they offered immediate advantages in studying all the three aspects of heredity: the generation, expression, and transmission of biological variation. This paper deals with the strength of microbial genetics: both prokaryotic as well as eukaryotic.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-303 Genetics of Microorganisms	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Classical genetics in microbes	10
II	Molecular genetics and tools	8
III	Art and design of genetic screens	18
IV	Quorum sensing and immunity in bacteria	9
Tutorials		
	Various modalities	15

Course outcomes : On completing 'Genetics of Microorganisms', the students would have:

- A clear understanding of how genes are transferred and mapped in bacteria and how bacteriophages contribute to genetic recombination and regulation.
- Working knowledge of molecular genetics tools using eukaryotic model microbe, yeast as a model system for identification gene function, cloning, expression control, and genome manipulation.
- The ability to design and interpret genetic screens to uncover gene function and genetic interactions in cellular pathways.
- An integrated understanding of quorum-sensing, bacterial signal transduction, biofilm formation and regulation, immune strategies in bacteria.
- Practical experience in genetic screening and inheritance analysis using yeast to distinguish nuclear and cytoplasmic genetic control.

Content (Theory)**45 hours**

- I. Classical Genetics in Microbes (10 hours)**
- Conjugation - Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination
 - Chromosome transfer in other bacteria
 - Transformation- Natural transformation systems, biology and mechanism of transformation, transformation and gene mapping, chemical-mediated and electro-transformation
 - Transduction: Discovery, generalized and specialized or restricted transduction, phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction;
 - Temperate phage lambda and mechanism of specialized transduction
 - Gene mapping, Fine-structure mapping
 - Techniques for studying bacteriophages- Virulent phage (T4) and temperate phage (phage lambda)
 - Important aspects of lytic cycle, phage-host relationships, immunity and repression site specific recombination (lambda and P1).
- II. Molecular genetics and tools (8 hours)**
- Yeast as an experimental system for eukaryotic molecular biology
 - Yeast cloning and expression vectors
 - Regulatable promoters
 - Construction of genetically modified strains
 - Generation of conditional alleles
 - Cosmids and yeast artificial chromosomes
 - Yeast one-, two- and three-hybrid systems
 - Mating-Type Genes and MAT Switching in *Saccharomyces cerevisiae*, HML, HMR and MAT loci, HO endonuclease, regulation of switching.
- III. Art and design of genetic screens (18 hours)**
- Choice of mutant phenotypes
 - Cloning by complementation
 - Isolation of bypass and allele specific-suppressors
 - Synthetic lethal screens
 - Use of these tools to isolate genes in the protein secretion pathway in yeast.
- IV. Quorum sensing and immunity in bacteria (9 hours)**
- Examples from *Vibrio harveyi* and *Vibrio fischeri*
 - Regulation of biofilm formation in *Vibrio cholera*
 - Two component signal transduction system
 - Discovery of CRISPR-Cas and its role in bacterial immunity.

- Content (Tutorial)**15 hours**

- Addressing individual queries on class concepts
- Discussing research papers on seminal work using genetic principles to understand protein secretion

- Secretion and cell-surface growth are blocked in a temperature-sensitive mutant of *Saccharomyces cerevisiae* doi: 10.1073/pnas.76.4.1858
- Order of events in the yeast secretory pathway doi: 10.1016/0092-8674(81)90064-7
- Cloning by complementation exemplified by identification of SEC14 gene (Rab Protein) doi: 10.1083/jcb.108.4.1271
- A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum doi: 10.1083/jcb.105.2.633
- **Discussing research papers on seminal work using genetic principles to understand quorum sensing**
 - Intercellular signalling in *Vibrio harveyi* doi: 10.1111/j.1365-2958.1993.tb01737.x.
 - Multiple signalling systems controlling expression of luminescence in *Vibrio harveyi* doi: 10.1111/j.1365-2958.1994.tb00422.x
- **Discussing research papers on seminal work using genetic principles to understand bacterial immunity**
 - CRISPR Provides Acquired Resistance Against Viruses in Prokaryotes doi: 10.1126/science.1138140
 - The CRISPR/Cas bacterial immune system cleaves bacteriophage and plasmid DNA doi: 10.1038/nature09523
 - A Programmable Dual-RNA–Guided DNA Endonuclease in Adaptive Bacterial Immunity doi: 10.1126/science.1225829
 - The *Streptococcus thermophilus* CRISPR/Cas system provides immunity in *Escherichia coli* doi:10.1093/nar/gkr606
 - Cas9–crRNA ribonucleoprotein complex mediates specific DNA cleavage for adaptive immunity in bacteria doi:10.1073/pnas.1208507109
- **Discussing relevant video content exemplified by**
 - Nobel Prize Inspiration Initiative lecture by Laureate Randy <https://www.youtube.com/watch?v=Udg6bYkBtX8>
 - Cell-Cell Communication in Bacteria via Quorum Sensing <https://www.ibiology.org/microbiology/quorum-sensing/>
 - The CRISPR Apostle: Rodolphe Barrangou <https://www.ibiology.org/microbiology/crispr-apostle/>
 - Genome Engineering with CRISPR-Cas9: Birth of a Breakthrough Technology <https://www.ibiology.org/genetics-and-gene-regulation/crispr-cas9/>

Essential Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.

Suggested Reading

1.	Microbial Genetics (Unit I, II, III, IV)	Maloy S, Cronan J & Freifelder D	Jones and Bertlett
2.	Fundamental Bacterial Genetics (Unit I, IV)	Trun N & Trempy J	Blackwell Publ.
3.	Modern Microbial Genetics (Unit II, III)	Streips U N & Yasbin RE	Wiley-Liss
4.	Molecular Genetics of Bacteria (Unit I)	Sneider L & Champness W	ASM Publishers
5.	Genetics of Bacteria (Unit I)	Scaife J	Academic Press
6.	Genetics of Bacteria and Viruses (Unit I)	Birge EA	Springer
7.	Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit II, III)	Guthrie C & Fink GR (Eds.)	Elsevier

DSE-GEN-304

Plant Genetics and Breeding

Course Objective: This course introduces students to the classical and contemporary principles of plant genetics and breeding. It covers natural breeding systems, gene pools, chromosome manipulation, heterosis, and conventional breeding strategies, while integrating advanced genomic and quantitative approaches, including QTL mapping, GWAS, genomic selection, phenomics, G×E analysis, and gene-editing-enabled breeding. The course is designed to provide a holistic understanding of how modern plant breeding combines genomics, statistics, and biotechnology to accelerate crop improvement and generate climate-resilient, high-yielding varieties.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-304 Plant Genetics and Breeding	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Historical perspective	4
II	Natural and conventional breeding strategies for trait introgression	13
III	Cytogenetic and chromosome manipulation approaches	5
IV	Molecular/genomics-assisted and heterosis breeding for crop improvement	23
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Plant Genetics and Breeding', the students would have:

- A clear understanding on tracing the historical development of plant breeding from early domestication to molecular and genomic eras and assess the importance of germplasm resources
- Learnt about Natural Breeding Systems, and Conventional Breeding Approaches
- Developed the aptitude for developing cytogenetic approaches and chromosome engineering
- Acquired the ability to apply basic concepts for molecular and genomics-assisted breeding

Content (Theory)**45 hours****I. Historical perspective (4 hours)**

- Importance and evolution of plant breeding.
- Major milestones: Mendelian genetics, chromosomal theory, quantitative genetics, Green Revolution, hybrid breeding.
- Transition from classical breeding to molecular and genomic eras.
- Role of genetic diversity and domestication in crop improvement.

II. Natural/conventional breeding methods and the gene pool concept (13 hours)

- Modes of reproduction in crop plants; self-pollination, cross-pollination, mixed mating, and apomixis.
- Consequences of breeding systems for homozygosity, heterozygosity, genetic load, and population structure.
- Applications of breeding systems in designing breeding strategies, including for climate-resilient cultivar development.
- Gene pool concept (primary, secondary, tertiary) and its relevance to trait introgression.
- Germplasm of major crops: cultivated types, landraces, wild relatives; pre-breeding strategies.
- Breeding methods for self-pollinated crops: mass selection, pure-line selection, pedigree method, bulk method, single-seed descent.
- Breeding methods for cross-pollinated crops: recurrent selection (simple, reciprocal, half-sib, full-sib), synthetic and composite varieties.
- Breeding vegetatively propagated crops: clonal selection and improvement strategies.

III. Cytogenetic and chromosome manipulation approaches (5 hours)

- Haploidy and doubled haploidy: production methods and use of DH lines in breeding.
- Polyploidy: auto- and allopolyploids, chromosome doubling, and applications in crop improvement.
- Wide hybridization: barriers to interspecific/intergeneric crosses and methods to overcome them (embryo rescue, ovule culture).
- Cytogenetic tools: karyotyping, meiotic pairing analysis, alien addition and substitution lines, induced translocations, and chromosome engineering.
- Applications of cytogenetic approaches in transferring stress-tolerance and other traits from wild relatives.

IV. Molecular/genomic and heterosis plant breeding (23 hours)

- Concepts and theories of heterosis at genetic, biochemical, and molecular levels.
- Combining ability (general and specific), heterotic groups and patterns.
- Hybrid breeding systems: CMS, GMS, TGMS; restorer lines; hybrid seed production technology.
- Molecular markers (SSR, SNP, indels): principles, strengths, limitations, and applications.
- Genetic linkage, mapping functions, and mapping populations (F_2 , RILs, NILs, DHs).
- Linkage mapping and QTL analysis: detection, effect estimation, and fine mapping.
- Association mapping/GWAS: linkage disequilibrium, population structure, and correction for confounding.

- Quantitative genetic parameters relevant to molecular/genomics-assisted breeding: heritability, genetic variances, and response to selection.
- Marker-assisted selection (MAS), marker-assisted backcrossing (MABC), and strategies for minimizing linkage drag; Marker-assisted recurrent selection (MARS) and gene pyramiding for complex traits.
- Genomic selection (GS) and genomic prediction: training populations, statistical models, validation, and deployment.
- Role of phenomics, multi-environment testing, and genotype × environment interactions in genomics-assisted breeding.
- Integration of gene editing (CRISPR/Cas), speed breeding, and high-throughput phenotyping into modern breeding pipelines.
- Use of integrative genomic approaches for developing climate-smart cultivars.

Content (Tutorial)

15 hours

- **Addressing individual queries and clarifying concepts from lectures.**
- **Discussion of classical and modern research papers in plant genetics and breeding (e.g., success stories of hybrid development, QTL mapping, MAS, and GS). These include, but are not limited to:**
 - Doebley, J. F., Gaut, B. S., & Smith, B. D. (2006). The molecular genetics of crop domestication. *Cell*, 127(7), 1309–1321. doi: 10.1016/j.cell.2006.12.006
 - Forster, B. P., & Thomas, W. T. B. (2005). Doubled haploids in genetics and plant breeding. *Plant Breeding Reviews*, 25, 57–88. doi: 10.1002/9780470650301.ch3
 - Meuwissen, T. H. E., Hayes, B. J., & Goddard, M. E. (2001). Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, 157(4), 1819–1829. doi:10.1093/genetics/157.4.1819
 - Yu, J., Pressoir, G., Briggs, W. H., et al. (2006). A unified mixed-model method for association mapping that accounts for multiple levels of relatedness. *Nature Genetics*, 38(2), 203–208. doi: 10.1038/ng1702
- **Problem-solving sessions on designing breeding schemes, calculating basic quantitative genetic parameters, and interpreting mapping results.**
- **Demonstrations (through published examples/videos) of phenotyping platforms and integration of molecular data in breeding decisions.**
 - Genetics is Shaping Agriculture and Food | https://www.ted.com/talks/sanushka_naidoo_genetics_is_shaping_agriculture_and_food
 - Breeding Climate-Resilient Crops | <https://www.youtube.com/watch?v=x9lxJcnZMoA>
 - How Technological Change Drives Improvement in Plant Breeding & Agriculture | <https://www.youtube.com/watch?v=bbr1HPNmF8>
 - Genotyping-by-Sequencing (GBS) Explained | <https://www.youtube.com/watch?v=jb7y1USeCBE>
 - What is Marker-Assisted Selection? (CIMMYT) | <https://www.youtube.com/watch?v=0uZcM2E-H2c>

- How Genomic Selection Works in Plant Breeding (CIMMYT) | <https://www.youtube.com/watch?v=pVY6gWgRVYo>
- CRISPR: Gene Editing in Agriculture (Broad Institute) | <https://www.youtube.com/watch?v=jAhjPd4uNFY>
- High-Throughput Plant Phenomics (LemnaTec) | <https://www.youtube.com/watch?v=v0rWb7YwN5o>
- Speed Breeding for Crop Improvement | <https://www.youtube.com/watch?v=c4kCgF5bT2E>

Essential Readings

Plant Breeding: Theory And Practice (1 st edition) (Unit I, II, III, IV)	Neal C Stoskopf, Dwight T Tomes, B. R. Christie, Bertram R Christie	CRC Press (ISBN 9780367298470)
Recent research papers and reviews		

Suggested Readings

Principles of Crop Improvement (2 nd edition) (Unit II)	Norman Simmonds, J. Smartt	Wiley-Blackwell
Genome Mapping in Plants (Unit IV)	Andrew H. Paterson	Academic Press
Principles of Plant Genetics and Breeding (Unit I, II)	George Acquaah	John Wiley & Sons, Ltd.
Marker-Assisted Plant Breeding: Principles and Practices (Unit II)	BD Singh, AK Singh	Springer

SEMESTER 3;S3

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-305

Human Genetics and Genomic Technologies

Course Objective: *This course provides an advanced understanding of human genetics, integrating classical and complex inheritance patterns, pedigree analysis, modern genomic sequencing technologies, genome editing systems (including CRISPR-Cas platforms), and ethical, legal, and social implications (ELSI) in prenatal, clinical, and population contexts.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-305 Human Genetics and Genomic Technologies	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Foundations of human inheritance and pedigrees	10
II	Genetic mechanisms beyond simple Mendelism	10
III	Human genomics and sequencing technologies	10
IV	Genome editing and ethical, legal, and social issues (ELSI)	15
Tutorial		
Various modalities as given below		15

Course outcome : On completing 'Human Genetics and Genomic Technologies, the students would have:

- A clear understanding of how classical experiments and human pedigrees reveal chromosomal, molecular, and complex patterns of inheritance, including examples relevant to the Indian population.
- Working knowledge of human genomics, including major DNA sequencing platforms and basic interpretation of sequence quality metrics and variant types in health and disease.
- The ability to compare and apply genome editing tools such as ZFNs, TALENs, and CRISPR systems to modify specific loci in the human genome.
- An integrated understanding of how large-scale genomics projects and genome editing outcomes inform our view of human genetic variation and complex disease.

- Practical skills in evaluating ethical, legal, and social implications of human genomics and genome editing, and in articulating balanced, policy-aware recommendations for their responsible use.

Content (Theory)

45 hours

- I. **Foundations of human inheritance and pedigrees** (10 hours)
 - Historical foundations: Mendel's laws; Sutton-Boveri chromosomal theory; T.H. Morgan linkage/recombination; DNA as genetic material (Griffith, Avery-MacLeod-McCarty, Hershey-Chase)
 - Pedigree analysis: Standard symbols; constructing/interpreting pedigrees
 - Inheritance patterns: Autosomal dominant/recessive (features, examples including Indian contexts);
 - X-linked recessive/dominant (hemophilia, color blindness); Y-linked; mitochondrial (maternal transmission, heteroplasmy, threshold effects)
- II. **Genetic mechanisms beyond simple Mendelism** (10 hours)
 - Extensions: Incomplete dominance, codominance (e.g., blood groups); complementation; germline mosaicism
 - Penetrance/expressivity: Reduced/age-dependent penetrance; variable expressivity (neurofibromatosis); anticipation (repeat expansions)
 - Advanced mechanisms: Pleiotropy, locus/allelic heterogeneity; genomic imprinting (methylation, control regions);
 - Prader-Willi/Angelman syndromes (deletion/UPD/imprinting defects); epistasis; haploinsufficiency; dominant-negative mutations; synthetic lethality
 - loss of heterozygosity; genetic redundancy; catastrophic rearrangements (chromothripsis, chromoplexy)
- III. **Human genomics and sequencing technologies** (10 hours)
 - Sanger sequencing: Chain-termination, Phred scores, quality assessment
 - Illumina SBS: Library prep, bridge amplification, reversible terminators; 4/2/1 channel chemistries; read-length limits/signal decay; platforms (MiSeq vs NovaSeq)
 - Long-read technologies: Oxford Nanopore (ionic current, error patterns); PacBio/SMRT; applications (SV detection, phasing, isoforms); MinION vs PromethION
 - Emerging: Aviti/polony chemistries; library strategies (TruSeq/Trinity-class, indexing)
 - Human Genome Project: Goals, milestones; post-HGP (variation landscape: SNPs/indels/CNVs); GWAS (common disease-common variant, polygenic scores, limitations); cancer genomics implications
- IV. **Genome editing and ethical, legal, and social issues (ELSI)** (15 hours)
 - Editing platforms: ZFNs/TALENs (architecture, challenges); CRISPR-Cas9 (gRNA, PAM, NHEJ/HDR); base/prime editing; PCSK9 therapeutic example
 - CRISPR biology: crRNA/tracrRNA/spacer/Cas1-2 acquisition; advanced (pegRNA/nickase/RT in prime editing)
 - RNA-targeting: Cas13 advantages (reversibility); collateral cleavage; diagnostics (Sherlock/Cas12-13); dCas13-ADAR fusions (REPAIRv2, specificity) -
 - ELSI: Principles (autonomy, beneficence, etc.); confidentiality/privacy; prenatal/reproductive issues; predictive testing/minors; incidental findings;

thalassemia screening; surrogacy; cloning (reproductive/therapeutic); eugenics; organ banking; AI risk scores bias

Content (Tutorials)

15 hours

Addressing individual queries on class concepts

- Clarification of challenging lecture concepts (e.g., locus heterogeneity vs allelic heterogeneity, chromothripsis, read-length constraints, prime editing logic)
- Pedigree problem sets covering multiple inheritance modes, penetrance/expressivity, and risk calculations
- Short technology critiques: Comparing MiSeq vs NovaSeq, MinION vs PromethION, and short-read vs long-read applications · Evaluating sequencing quality using Phred scores and simple QC outputs
- Guided reading and discussion of landmark papers and case reports on HGP, GWAS, CRISPR genome editing, imprinting disorders, mitochondrial inheritance, and catastrophic genome rearrangements
- Structured ELSI case discussions (small groups) on prenatal diagnosis, predictive testing in minors, incidental findings, cloning, surrogacy, and eugenics
- Written and oral presentations on assignment prompts (therapeutic cloning, soft eugenics, AI-based risk scores)

Discussions on relevant academic resources, videos/ TED talks

- Discussions on landmark discoveries and milestones in human genetics and genomics
<https://www.youtube.com/watch?v=cR5An16ifj0>
- The Human Genome Project: A Decade Later | Francis Collins |
<https://www.youtube.com/watch?v=Gnt2SJkt83Q>
- CRISPR: Gene editing and beyond | Jennifer Doudna | TED
<https://www.youtube.com/watch?v=TdBAHexVYzc>
- The ethical dilemma of designer babies | Paul Knoepfler | TED
<https://www.youtube.com/watch?v=nOHbn8Q1fBM>
- Ethical dimensions of CRISPR and human genome editing | Various panel discussions
https://www.youtube.com/watch?v=LmMuTCn-N_M
- Sequencing the human genome:
<https://www.youtube.com/watch?v=aRWWldz2YZc>

Key Papers:

- International HapMap Consortium (2005), “A haplotype map of the human genome”, Nature 437, 1299–1320: doi:10.1038/nature04226
- 1000 Genomes Project Consortium (2015), “A global reference for human genetic variation”, Nature 526, 68–74: doi:10.1038/nature15393
- Lek et al. (2016), Exome Aggregation Consortium (ExAC), “Analysis of protein-coding genetic variation in 60,706 humans”, Nature 536, 285–291: doi:10.1038/nature19057
- Karczewski et al. (2020), gnomAD, “The mutational constraint spectrum quantified from variation in 141,456 humans”, Nature 581, 434–443: doi:10.1038/s41586-020-2308-7

Essential Reading

1.	Human Molecular Genetics (Unit I, II, III)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II, III, IV)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Reading

1.	Principles of Population Genetics (Unit I, II)	Hartl DL & Clark AG	Sinauer Associates
2.	Population Genetics: A Concise Guide (Unit I, II)	Gillespie JH	Johns Hopkins University Press
3.	Human Evolutionary Genetics (Unit II)	Jobling MA et al.	Garland Science
4.	An Introduction to Population Genetics (Unit I, II, III)	Nielsen R & Slatkin M	Sinauer Associates

SEMESTER 3;S3

GENERAL ELECTIVE

2Y-PG

GE-GEN-310

Genetics in Human Health

Course Objective: This elective paper has been designed to introduce students from other departments to the basic concepts in genetics, with a specific focus on human health. It also aims to provide an overview of the classical and contemporary genetic tools for the improvement of overall life quality. The various aspects of medical genomics focus on tools for genetic analysis of human disorders, the translation of findings for predictive, preventive, personalized, and participatory (P4) medicine, and cellular and animal models of disease for enhanced understanding of disease biology and the development of new therapeutics.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-GEN-310 Genetics in Human Health	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Characteristics of the human genome	3
II	Analysis of genetic disorders	21
III	Clinical cytogenetics and molecular diagnostics	14
IV	Modelling of human genetic disorders and intervention strategies	7
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Genetics in Human Health', the students would have:

- A clear understanding of human gene, genome, and chromosome structure, the principles of Mendelian and non-Mendelian inheritance, and the nature of genetic variation in human populations.
- Working knowledge of the molecular basis of human disease, including how different classes of mutation, genotype–phenotype correlations, and gene–environment and epigenetic interactions contribute to rare, common, and cancer-associated disorders.
- The ability to explain and apply major genomic technologies and diagnostic tests, interpret results for clinical use, and recognize key ethical, legal, and social dimensions of genetic testing, counselling, and personalized medicine.
- An integrated understanding of how diverse model organisms are used to mimic human disease mutations, explore conserved gene functions, and perform genetic or drug modifier screens using advanced genetic and genome editing tools.

GE-GEN-310

Genetics in Human Health

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- The ability to explain and apply major genomic technologies and diagnostic tests, interpret results for clinical use, and recognize key ethical, legal, and social dimensions of genetic testing, counselling, and personalized medicine.
- An integrated understanding of how diverse model organisms are used to mimic human disease mutations, explore conserved gene functions, and perform genetic or drug modifier screens using advanced genetic and genome editing tools.

Content (Theory)

45 hours

I. Characteristics of the human genome (3 hours)

- Introduction of human chromosomes, genes, and genomes.
- An overview of the genetic and molecular basis of syndromes and disorders

II. Analysis of genetic disorders (21 hours)

- Pedigrees: Symbols, construction of pedigrees,
- Inheritance patterns: Dominant, recessive, sex-linked and sex-limited patterns, mitochondrial inheritance.
- Complications to the basic pedigree patterns: Non-penetrance, variable expressivity, late-onset, genomic imprinting, mosaicism and chimerism, X-inactivation, risk assessment.
- Monogenic diseases with established molecular pathology: Cystic fibrosis, Tay-Sachs syndrome
- Polygenic and complex traits/ disorders: Polygenic inheritance, 'Nature -nurture' concept, monozygotic and dizygotic twins. Atherosclerosis, diabetes mellitus
- Genome imprinting syndromes: Prader-Willi and Angelman syndromes
- Repeat expansion disorders/ syndrome: Huntington's disease and fragile X-syndrome
- Genomic instability and cancer: Cell cycle checkpoint and cancer, oncogenes, tumour suppressor genes, DNA repair genes, and genetic instability
- Inborn errors of metabolism and their genetic basis: Phenylketonuria, maple syrup urine syndrome

III. Clinical cytogenetics and molecular diagnostic (14 hours)

- Cytogenetic and molecular diagnostics: Overview of prenatal, neonatal, and adult diagnosis strategies
- Human metaphase chromosomes: types and characteristics
- Human karyotype: banding types, pathology of human chromosomes, common syndromes due to numerical and structural alterations

IV. Modelling of human genetic disorders and intervention strategies (7 hours)

- Modelling of human genetic disorders/ diseases (such as cancer, neurodegenerative disorders) in *Drosophila*, zebrafish, and mouse.
- Screening of genetic modifiers, drug targets, and drugs.
- Management of genetic disorders: Genetic counselling, gene therapies, ethical, legal, and social issues

Content (Tutorial)

15 hours

- Addressing individual queries on class concepts
- Discussing research/ review papers on seminal work in the field of human genetics and medical genetics
- Duong D, Solomon BD. (2025) Artificial intelligence in clinical genetics. *Eur J Hum Genet.* 33(3):281-288. DOI: 10.1038/s41431-024-01782-w
- The Cell Editorial Team. Five decades of genetics and genomics. *Cell.* DOI: 10.1016/j.cell.2024.01.020
- Lamm, Ehud et al. "Before Watson and Crick in 1953 Came Friedrich Miescher in 1869." *Genetics.* 2020;215(2):291-296. DOI: 10.1534/genetics.120.303195
- Mayor, S. "First human chromosome is sequenced." *BMJ.* 1999;319(7223):1453a. DOI: 10.1136/bmj.319.7223.1453a
- Ponting CP. Human genetics seen through an evolutionary lens. *Cell Genom.* 2023;3(5):100323. DOI: 10.1016/j.xgen.2023.100323

- Drets ME, Shaw MW. (1971) Specific banding patterns of human chromosomes. Proc Natl Acad Sci U S A. 68(9):2073-2077. DOI: 10.1073/pnas.68.9.2073
- Cohen JS et al. (2022) Genomic answers for children: Dynamic analyses of >1000 pediatric rare disease genomes. Genet Med. 24(6):1336-1348. DOI: 10.1016/j.gim.2022.02.007
- Roth TL, Marson A. (2021) Genetic Disease and Therapy. Annu Rev Pathol. 16:145-166. DOI: 10.1146/annurev-pathmechdis-012419-032626
- Science Editorial – Modeling Human Disease. Science. DOI: 10.1126/science.1227179
- Discussions on relevant TED talks/ academic videos/ digital resources
 - Can we cure genetic diseases by rewriting DNA? By David R. Liu
<https://www.youtube.com/watch?v=ONs9FCY74p0>
 - The human journey-- a genetic odyssey: Spencer Wells at TEDxConnecticutCollege
<https://www.youtube.com/watch?v=xnbxrDGZoBQ>
 - How genetics and environment work together to shape our destiny: Milena Georgieva at TEDxAUBG <https://www.youtube.com/watch?v=gfDikwoAbPk>
 - The World's Rarest Diseases — And How They Impact Everyone | Anna Greka | TED
<https://www.youtube.com/watch?v=n0J1zCHURsQ>
 - The Power of a Genetic Diagnosis | Dr. Vincent Carson | TEDxLancaster
https://www.youtube.com/watch?v=CZ4O_h1wYoo
 - What Is Genetic Counseling? | Jaclyn Haven | TEDxHelena
<https://www.youtube.com/watch?v=7yIWOL9dLCQ>
 - The age of genetic wonder | Juan Enriquez | TEDxCERN
<https://www.youtube.com/watch?v=GPIVILKI5LE>

Essential Readings

1.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
2.	Genetics: A Conceptual Approach (Unit I, II)	Pierce BA W.H. Freeman	W. H. Freeman and Company

Suggested Readings

1.	iGenetics A Molecular Approach (Unit I, II)	Russell PJ	Pearson
2.	Human Molecular Genetics (Unit I, II, III, IV)	Strachan T & Read A	Garland Science
3.	Human Genetics (Unit I, II, III)	Ricki Lewis	McGraw Hill
4.	Medical Genetics (Unit III, IV)	Jorde et al.	Elsevier
5.	Genetics and Genomics in Medicine (Unit III, IV)	Cohn et al.	Elsevier
6.	New Clinical Genetics (Unit I, III, IV)	Andrew Read and Dian Donnai	Scion Pub Ltd
7.	Emery's elements of medical genetics and genomics (Unit I, III, IV)	Peter Turnpenny	Elsevier
8.	Evolution of Medical Genetics (Unit II, III)	Peter Harper	CRC Press
9.	Relevant Review and Research Papers (Unit I, II, III, IV)		

SEMESTER 3; S3

SKILL BASED COURSE

2Y-PG

SBC-GEN-311

Advanced Research Methodology

Course Objective: This course comes under the course type Skill-based course/ workshop/ Specialised laboratory/ Internship/ Hands on Learning. This course teaches essential steps of research in life sciences, from formulating questions to presenting findings. Conceptual teaching and hands-on activity based practical will be employed.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-311 Advanced Research Methodology	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		Teaching
I	Framing research questions	8
II	Data collection and analysis	7
Practical		
I	Analysing given sets of data and identifying problems within the data, if any	15
2	Research paper presentation	15

Course Learning Outcome: On completion of 'Research Methodology' students would have:

- Developed the ability to distinguish and choose between various study designs as suited for different studies
- Understood various sampling methods and their applications
- Demonstrated critical thinking and data analysis skills

Content (Theory)

I. Framing Research Questions

- Definition and purpose of scientific research
- Historical contributions of research in life sciences
- Difference between basic and applied research
- Ethics in life sciences research (human/animal subjects, environmental impact)
- Overview of the scientific method
- Identifying a research problem
- Literature review: finding and evaluating relevant studies
- Formulating hypotheses and objectives
- Experimental vs. bioinformatics approaches
- Characteristics of a good research question (specific, measurable, achievable, relevant, time-bound)
- Practical Activity: Hands-on literature review using PubMed/Google Scholar
- Types of research design: Experimental, observational, descriptive, correlational
- Study designs in life sciences: Cross-sectional, longitudinal, case-control, cohort studies
- Importance of sampling
- Types of variables
- Experimental and control groups
- Importance of removing bias and selecting controls in research
- Pilot studies and feasibility analysis
- Testing and validation

II. Data Collection and Analysis

- Primary vs. Secondary Data
- Data collection techniques
- Laboratory experiments
- Field studies, surveys, Interviews and questionnaires
- Follow standardized procedures for reproducibility
- Standard methods of recording data
- Use of databases and bioinformatics tools
- Data integrity and quality control

Content (Practical)

Unit I: Analysing given sets of data and identifying problems within the data, if any

Unit II: Task based exercises on study design and analyzing given research papers

Essential Reading

- | | | | |
|----|---|---------------------------|-------------------------|
| 1. | A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods (Unit I, II) | Mukherjee , Shyama Prasad | Taylor and Francis 2020 |
| 2. | Research Methodology: The Aims, Practices and Ethics in Science (Unit I, II) | Peter Pruzan | Springer 2016 |

Suggested Reading

Various research papers as suggested by the teacher in classroom

SEMESTER 3; S3

TR-GEN-312

2Y-PG

Research Laboratory Practices and Instrumentation

Course objective: Working in a research laboratory with a team demands implementation of good practices to ensure optimum quality of data and safe working environment. Learning to work with various instruments requires a good understanding of the basic principles, strength and weakness of the equipment. In this course an overall knowledge that empowers a student to work confidently in any research environment will be inculcated

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
TR-GEN-312 Research Laboratory Practices and Instrumentation	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		Teaching
I	Research Laboratory Practices, Skills and Safety	7
II	Instrumentation	8
Practical		
1	Hands-on essentials for research laboratory work	15
2	Using instruments to study biological processes	15

Course Outcome: At the end of the 'Research Laboratory Practices and Instrumentation' course the students would have

- Developed an understanding of the importance of good laboratory practices in the research setting with respect to quality of data
- Developed an understanding of the importance of good laboratory practices in the research setting with respect to safety
- Augmented their theoretical and hands-on experimental skillset with an in-depth understanding on the principles of various instruments

Content (Theory)**15 hours****Unit I: Research Laboratory Practices Skills and Safety (7 hours)**

- Laboratory organization, cleanliness, and workflow.
- Biosafety levels, warning signs, and risk categories.
- Safe handling and disposal of biological and chemical materials.
- Working under aseptic conditions.
- Use of personal protective equipment (PPE) and emergency response protocols.
- Preparation and labelling of reagents, solutions, and samples.
- Maintenance of laboratory notebooks and data recording.
- Basic data organization, spreadsheet use, and graphical representation of results.
- Concepts of accuracy, precision, and error minimization in experiments.
- Common culture media and nutrient formulations

Unit II: Instrumentation (8 hours)

- Principles, operation, and safety considerations for:
 - Water purification systems
 - Centrifuges (bench-top, refrigerated, ultracentrifuge)
 - Spectrophotometers and Nanodrop instruments
 - Electroporator
 - Sonicator
 - Autoclaves, incubators, and refrigerators/freezers
- Calibration and care of common laboratory equipment
- Maintenance procedures

Content (Practical)**30 hours****Unit I: Hands-on essentials for research laboratory work**

- Cell counting techniques
- Comparative
- Limit of detection of cells and biological materials
- Concentration units: molarity, normality, and percentage solutions.
- Preparation of stock solutions and working dilutions.
- pH measurement, adjustment, and buffer capacity.
- Calculations and Preparation of reagents and common laboratory buffers (PBS, Tris, TE).

Unit II: Using instruments to study biological processes

- Demonstration of flow cytometry
- Demonstration of in situ hybridization
- Studying Chemotaxis
- Studying Phototaxis
- Studying development in different conditions: agar, filter or submerged
- Demonstration of Chimera studies

Essential Reading:

- | | | | |
|----|--|-------------------------|--|
| 1. | Principles and Techniques of Biochemistry and Molecular Biology | Wilson K, Walker J, eds | Cambridge University Press
1987 (7 th edition) |
| 2. | Dictyostelium discoideum: Molecular Approaches to Cell Biology. Methods in Cell Biology Book | Spudich J | Academic Press
1987 |

Suggested Reading:

1. Various instrument manuals available with the instruments of the Department
2. Biosafety manuals as prescribed by University of Delhi and other organizations

SEMESTER 3; S3

RESEARCH PROJECT

2Y-PG

RP-GEN-313-S3

Research Project (Structure 3)

Course Objective:

The objective of this **project work in Semester 3 and Semester 4 of Structure 2** is to provide hands-on experience to the students about handling a research problem. The students will be encouraged to design and carry out a small research project around a topic being investigated in the allotted lab under the supervision of the faculty member. The students are expected to present their objectives and experimental design before initiation of the experimental work. After completion, the students are expected to present their findings as a presentation and report in Semester 4, a continuation of their assigned work.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RP-GEN-313-S3 Research Project (Structure 3)	10	0	0	10	B.Sc in any branch of science	NA

Components of evaluation of research work		
Semester 3		
	Preparation and Presentation of Outline of Research Work	
	Internal assessment of mentor	
	Interim report submission & evaluation	
	Presentation and viva-voce	
Semester 4 (continued from Sem 3)		
	Internal assessment of mentor	
	Thesis submission & evaluation	
	Presentation and viva-voce	

Course outcome: On completion of the 'Research Project' the students :

Will be able to ask questions, design experiments, perform them, trouble shoot, analyze data and present the work both in oral and written form.

The student will carry out an independent piece of experimental work in the laboratory of an allotted supervisor. Supervisors for the project work will be based on draw of lots or as decided by the department. The students are expected to make two presentations, and

submit a detailed report of the research work executed in one semester. The work will also be assessed on a continuous basis.

SEMESTER 4 (2Y-PG)					
Structure 3- Research					
Distribution of credits that a student needs to complete under course types					
Course Distribution	Core (DSC)	Electives (DSE/GE)	2-Credit core course (2CC)	Research Project (R)	Total
Number	0	1 (1DSE+0GE; 0DSE+1GE)	1	1	5
Credits	0	4	2	16	22
Student needs to complete 0+4+2+16 = 22 credits					

PAPERS OFFERED						
Course Code	Type	Title	Credits	Credit distribution		
				Th	P	T
DSE-GEN-403	DSE	Advances in <i>Drosophila</i> genetics	4	3	0	1
DSE-GEN-404	DSE	Biology of Dictyostelium	4	3	0	1
DSE-GEN-405	DSE	Cancer Biology and Genetics	4	3	0	1
DSE-GEN-406	DSE	Molecular plant-microbe interaction	4	3	0	1
DSE-GEN-407	DSE	Yeast genetics	4	3	0	1
GE-GEN-410	GE	Basic Science to Biological Applications (offered only to students of other departments)	4	3	0	1
SBC-GEN-411	2CC	Scientific Writing and Presentation	2	1	1	0
RP-GEN-413-S3	RP	Research Project	16	0	16	0

Course Distribution and Overview

1 credit = 15 hours of teaching/ 30 hours of practical/ 15 hours of tutorials

DSE-GEN- 403

Advances in *Drosophila* Genetics

Course Objective: This specialized paper has been designed to provide an advanced understanding of contemporary *Drosophila* genetics and related areas. *Drosophila* has been one of the favored model organisms of geneticists since T. H. Morgan decided to use it in 1910 to investigate the chromosomal theory of inheritance. Thereafter, succeeding generations of “*Drosophilists*” have developed an ever-increasing repertoire of techniques that make *Drosophila* as an indispensable and one of the most tractable multicellular organisms for biomedical research.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-403 Advances in <i>Drosophila</i> Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	<i>Drosophila</i> : An indispensable organism for biomedical research	6
II	Molecular genetics of <i>Drosophila</i> gametogenesis and development	20
III	<i>Drosophila</i> -specific genetic toolkits for functional analysis of genes	10
IV	<i>Drosophila</i> as a model for human genetic disorders, drug screening, aging, and behavioral studies	9
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing ‘Advances in *Drosophila* Genetics’, the students would have:

- Developed a comprehensive understanding of the historical, genetic, and biomedical significance of *Drosophila melanogaster*
- Acquired an integrated understanding of molecular genetic mechanisms underlying development and regulatory processes across life stages.
- Developed the ability to use genetic and molecular approaches to interpret spatial and temporal control of genes.
- Expanded their proficiency in applying advanced genetic tools and genome engineering strategies.
- Understood the capacity of *Drosophila* to model human genetic diseases for therapeutic implications.

Content (Theory)**45 hours**

- I. *Drosophila*: An indispensable organism for biomedical research** 6 hours
- An Introduction- Historical perspective, an overview of the life cycle and advantages in genetic analysis, developmental studies, and biomedical research, the nomenclature of genes and mutations, balancer and marker chromosomes and associated common phenotypes, strategies to design genetic crosses, and an overview of *Drosophila*-specific online databases, stock centers, and other resources.
- II. Molecular genetics of *Drosophila* gametogenesis and development** 20 hours
- Axis specification and cellular signalling during oogenesis- *Drosophila* female reproductive system, an overview of the oogenesis and stage identification, selection of potential oocyte, somatic and germ cell derivatives
 - Delta, JAK/STAT, Notch signalling and specification of A/P polar cells and axis determination, ring canals, transportation and localization of transcripts and protein in the oocyte, Gurken signalling and axis determination, border cell migration, cytoplasmic dumping, and oocyte maturation. Analysis of some female sterile mutant lines.
 - Cellular remodelling and differentiation during spermatogenesis-*Drosophila* male reproductive system, mitotic and meiotic cell divisions, spermatogonia, spermatocytes, cyst cell, mitochondrial remodelling, nebenkern, nuclear shaping, actin polymerization, sperm individualization.
 - Overview of embryogenesis, axis formation, and fate map.
 - Genetic hierarchy of development in *Drosophila*- egg polarity genes, the establishment of morphogen gradient, gap genes, pair-rule genes, specification of stripes, regulation of pair-rule gene expression, segment polarity genes, the establishment of segment polarity, homeotic genes, and mutations, antennapedia/bithorax complex, and specification of body organs
 - Larval stages and tissue types, imaginal discs - development and differentiation, axis determination in imaginal discs, regeneration and trans-differentiation, adult morphology, and internal organs
- III. *Drosophila*-specific genetic toolkits for functional analysis of genes** 10 hours
- Genetic tools- Genetic tools for studies on gene expression
 - Generation and analysis of FLP/FRT-mediated somatic clones. MARCM (Mosaic analysis with a repressible cell marker), Generation and analysis of ovoD-mediated germ-line clones
 - Conditional and/or targeted over-expression/ablation of genes/transcripts (e.g. UAS/GAL4/GAL80 system)
 - RNAi-based screening of gene functions, *Drosophila* genome editing by CRISPR-Cas9
 - Stem cells and their maintenance- Somatic and germline stem cells
 - Components and functions of stem cell niches
 - Stemness, Various cellular signalling (i.e. Delta-Notch, JAK-STAT etc.), and maintenance of stemness
 - Differentiation of stem cells and maintenance of organ homeostasis
 - Therapeutic usages of stem cells
 - *Drosophila*- a model system to study immune responses, Induction of immune response, antimicrobial defence, Toll, and Immunodeficiency (IMD) signalling pathways.

IV. *Drosophila* as a model for human genetic disorders, drug screening, aging, and behavioral studies

9 hours

- Modeling of neurodegenerative disorders (i.e. Parkinson's, Huntington's, Alzheimer's diseases etc.), fragile-X syndrome, cancer, mitochondrial dysfunction, cardiac and muscular diseases etc
- Screening and identification of modifier genes, drug targets, and drug molecules
- *Drosophila* in drug screening and toxicological studies, Circadian rhythm in *Drosophila*
- Usages of *Drosophila* in behavioral genetics and aging research

Content (Tutorial)

15 hours

- **Addressing individual queries on class concepts**
- **Discussing research papers on seminal work in the field, exemplified by the following**
 - Morgan TH. (1910) Sex limited inheritance in *Drosophila*. *Science*. 1910 Jul 22;32(812):120-2. <https://www.science.org/doi/10.1126/science.32.812.120>
 - Lewis EB. (1978) A gene complex controlling segmentation in *Drosophila*. *Nature*. 276(5688):565-70. <https://www.nature.com/articles/276565a0>
 - Konopka RJ, Benzer S. (1971) Clock mutants of *Drosophila melanogaster*. *Proc Natl Acad Sci U S A*. 68(9):2112-6.
 - Victor Atoki et al., (2025) Exploring the versatility of *Drosophila melanogaster* as a model organism in biomedical research: a comprehensive review. *Fly (Austin)*. 19(1):2420453. <https://doi.org/10.1080/19336934.2024.2420453>
 - Brumby AM, Richardson HE. (2005) Using *Drosophila melanogaster* to map human cancer pathways. *Nat Rev Cancer*. 5(8):626-639. <https://www.nature.com/articles/nrc1671>
 - Kimble J, Nüsslein-Volhard C. (2022) The great small organisms of developmental genetics: *Caenorhabditis elegans* and *Drosophila melanogaster*. *Dev Biol*. 485:93-122. <https://doi.org/10.1016/j.ydbio.2022.02.013>
 - Suzuki, DT. (1970) Temperature-sensitive mutations in *Drosophila melanogaster*. *Science*, 170:695-706. <https://www.science.org/doi/10.1126/science.170.3959.695>
 - Hales KG, Korey CA, Larracuenta AM, Roberts DM. (2015) Genetics on the fly: A primer on the *Drosophila* model system. *Genetics*. 201:815 <https://doi.org/10.1534/genetics.115.183392>
 - Bellen HJ, Tong C, Tsuda H. (2010) 100 years of *Drosophila* research and its impact on vertebrate neuroscience: a history lesson for the future. *Nat Rev Neurosci*. 11:514-22. <https://www.nature.com/articles/nrn2839>
- **Discussions on relevant academic resources, videos/ TED talks**
 - Discussions on Nobel Prize-winning discoveries using *Drosophila* as a model organism.
 - The why of the fly | Daniel N. Cox | TEDxGeorgeMasonU <https://www.youtube.com/watch?v=UMeS1gBdzgk>
 - Eric Wieschaus (Princeton) Part 1: Patterning Development in the Embryo <https://www.youtube.com/watch?v=Ncxs21KEj0g>
 - Eric Wieschaus (Princeton) Part 2: Stability of Morphogen Gradients & Movement of Molecules <https://www.youtube.com/watch?v=cpOf5el9Gik>
 - The Fruit Fly as Human Disease Research Tool, Harvard University Educational Video <https://www.youtube.com/watch?v=0cte6rowhao>

- *Drosophila* circadian rhythms, memory and disease models. Faculty of Life Sciences, University of Bristol. <https://www.youtube.com/watch?v=MoS-9HgZCro>
- Drugs, dopamine and *Drosophila* - A fly model for ADHD? | David Anderson | TEDxCaltech https://www.youtube.com/watch?v=L8Bd_p8pbQI
- Eric Wieschaus and Christiane Nüsslein-Volhard: Collaborating to Find Developmental Genes <https://www.youtube.com/watch?v=GmQ9eI1vdGM>

Essential Reading

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of <i>Drosophila melanogaster</i> (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
<i>Drosophila</i> Guide (Unit I)	Demerec & Kaufmann	Carnegie Press
<i>D. melanogaster</i> : Practical Uses in Cell and Molecular Biology (Unit I, II, III, IV)	Goldstein & Fyrberg	Academic Press
The making of a fly: The genetics of animal design (Unit III, IV)	Lawerence	Blackwell
<i>Drosophila</i> : Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of <i>Drosophila</i> Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
<i>Drosophila</i> : A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

DSE-GEN- 404

Biology of Dictyostelium

Course Objective: The course is designed to provide some fundamental principles to form an integrated view of various genetic and molecular processes using *Dictyostelium discoideum* as a model system. Tutorials would be in the form of discussions on research and review papers related to each topic, highlighting the advances made in the field.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Biology of Dictyostelium	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	hours
Theory		
I	Introduction to <i>Dictyostelium</i>	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	<i>Dictyostelium</i> in biology and medicine	3
Tutorial		
	Various modalities as given below	15

Course outcomes : On completing 'Biology of Dictyostelium', the students would have:

- Appreciated the classical experiments, emergence of *D. discoideum* as a model organism
- Acquired an in-depth understanding of structural, cellular, biological and regulatory mechanisms of *D. discoideum*
- Developed an understanding of how *D. discoideum* cells respond to nutrient cues using novel and conserved signaling pathways for development and features for cell differentiation.
- Ascertained the relevance of *D. discoideum* as a model system for human diseases

Content (Theory)**45 hours****I. Introduction to *Dictyostelium* (8 hours)**

- An overview; *Dictyostelium discoideum* and its relatives
- History of research on *D. discoideum*
- Classical experiments of Kenneth Raper; Chemotaxis and aggregation
- Evolution and Genome
- Life cycle
- Molecular techniques

II. Cellular organization and initiation of developmental process (9 hours)*Cellular organization and Dynamics*

- Plasma membrane, channels and pumps, macropinocytosis, phagocytosis; Lysosomes; The autophagic vacuoles; Cytoskeletal proteins; Cytokinesis; Cell motility

Initiation of Development

- Transition from growth to development, detection of starvation, events after starvation, Cellular and molecular mechanisms; Factors controlling early development; Sexual development, macrocyst formation

III. Developmental processes and signaling pathways**(23 hours)***Chemotaxis and Aggregation*

- Components of cAMP signal transduction and relay pathway, Secondary messengers and cytoskeletal events; Role of PKA; Developmental regulation of chemotactic components; Role of cGMP and calcium in chemotaxis; Polarity of movement

Cell adhesion and Recognition

- Cell adhesion molecules, cell-cell contact and gene expression; Cell recognition in the sexual development

Signal transduction

- Diffusible molecules
- cAMP signaling, cAMP oscillation and signal relay
- control of aggregation, cell sorting, coordinated cell movement during multicellular morphogenesis
- Prespore gene expression
- Peptide signaling

Cell differentiation and Pattern formation

- Initial cell type choice, cell type specific markers, Cell fate determination
- DIF signaling, DIF-1 and prestalk gene expression
- Prestalk and stalk cell heterogeneity
- Calcium in pattern formation and various models for pattern formation
- Coordinated cell movement and Morphogenesis

IV. *Dictyostelium* in biology and medicine (3 hours)**Content (Tutorial)****15 hours**

- Addressing individual queries on class concepts

- Discussing research papers on seminal work in the field
- Images and videos for learning life cycle, cell differentiation, chemotaxis and other events during growth and developmental
 - A video on *Dictyostelium discoideum*- a slime mold) <https://www.youtube.com/watch?v=5h8WOWEqP6o>
 - John Bonner’s slime mold videos <https://www.youtube.com/watch?v=bkVhLJLG7ug>
 - Coronin and phagocytosis <http://dictybase.org/Multimedia/phagocytosis/gerisch4.avi>
 - cell tracks and a moving slug http://dictybase.org/Multimedia/development/on_agar_cell_tracks.mov
 - Aggregation towards cAMP <http://dictybase.org/Multimedia/development/ax320x.mov>
 - Chemotaxis of large field of cells <http://dictybase.org/Multimedia/development/agg.mpg>
 - Movement of cells during morphogenesis <http://dictybase.org/Multimedia/development/culm.mov>
 - Dictyostelium development http://dictybase.org/Multimedia/development/Dd%20timelapse%206%20days_Kaks_onen.mp4
 - Prestalk cells in slugs <http://dictybase.org/Multimedia/morphogenesis/weijer1.avi>

Essential Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium discoideum</i> : molecular approaches to cell biology. <i>Volume 28 of Methods in Cell Biology</i> (Unit I, II, III)	James A Spudich	Academic Press

Suggested Readings

1.	<i>Dictyostelium</i> , Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	<i>Dictyostelium</i> -A model system for cell and developmental biology (Unit I, II, III, IV)	Yasuo Maeda, Kei Inouye and Ikuo Takeuchi (Eds)	Universal Academic Press, Inc. Tokyo Japan
3	Research papers (Unit I, II, III, IV)		

SEMESTER 4; S3

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-405

Cancer Biology and Genetics

Course Objective: *Comprehensive genetic and molecular analysis of tumor progression and advances in technology, have contributed to our understanding of various pathways and molecules. These have been exploited for their therapeutic leading to considerable improvement in patient survival and management for some cancers. In this course, the students get familiar with various aspects of oncology with an emphasis on genetics, biology, diagnosis, prevention and therapy of cancers.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-404 Cancer Biology and Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Epidemiology, etiology, diagnosis and molecular pathology of cancer	10
II	Mechanistic basis of oncogenesis	15
III	Biology of tumour progression	10
IV	Advances in cancer diagnostics and therapy	10
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Cancer Biology and Genetics’, the students would have:

- Developed a clear understanding of how cancers originate and are classified, and how various factors contribute to disease development and diagnosis.
- Gained insight into the biological mechanisms and genetic basis of cancer initiation, uncontrolled cell growth and tumor formation.
- Understood how tumors progress and spread, and how interactions with surrounding tissues and metabolism influence disease outcome.
- Appreciated the role of the immune system in controlling cancer and the strategies tumors use to escape immune recognition.
- Acquired an overview of modern approaches to cancer diagnosis and treatment, and how molecular knowledge has shaped current and emerging therapeutic strategies.

Content (Theory)

- I. Etiology and molecular pathology of cancer**
 - Pathology of tumor/cancer tissues
 - Classification of tumor/cancers; major cancer types
 - Approaches for cancer diagnostics and tumor markers
 - Molecular pathology -Molecular and diagnostic markers
 - Influence of environment and lifestyle changes
 - Broad overview of environmental, chemical, physical, infectious, genetic, and lifestyle risk factors; concept of multistep carcinogenesis and latency.
 - Cancer and Aging
- II. Mechanistic basis of oncogenesis**
 - Classical and new hallmarks of cellular transformation
 - Chromosomal rearrangements, Mutations, Aneuploidy
 - Genetic basis of oncogenesis – historical theories, discovery of tumor suppressors and oncogenes
 - Multistage tumorigenesis and tumor evolution
 - Hereditary and familial cancers
 - Viral theory of carcinogenesis- discovery of tumor suppressors and oncogenes
 - DNA repair defects and mutator hypothesis - Loss of heterozygosity analysis, allelotyping, microsatellite instability
- III. Biology of tumor progression**
 - Signalling pathways of cancer
 - Cancer progression: Metastatic cascade, Angiogenesis, Epithelial to mesenchymal transformation
 - Tumor microenvironment – Warburg effect, immune and other cells, inflammation and hypoxia
 - Role of immune system in preventing tumor growth
 - Acquired escape mechanisms against immune surveillance
 - Tumor antigens and T cell activation
- IV. Advances in cancer diagnostics and therapy**
 - Mutational signatures; driver and passenger mutations; heterogeneity
 - Cancer treatment modalities and assessment of prognosis
 - Targeted therapy and synthetic lethality
 - Mechanisms of resistance
 - Examples of cancer treatment and their evolution based on molecular and technological advances.

Content (Tutorials)

The tutorials in this course are designed to encourage the students to take a holistic approach to learning about cancer by understanding the role of the researcher, oncologist and the patient.

- Discussions on books such as:
 - a. Rebel Cell: Cancer, Evolution, and the New Science of Life's Oldest Betrayal by Kat Arney (Author) ISBN-13978-1950665303

- b. The Emperor of All Maladies : A Biography of Cancer (Winner of the Pulitzer Prize for Non-fiction 2011) Edition 2011 by Siddharth Mukherjee ISBN-13978-0007250929
- c. The Immortal Life of Henrietta Lacks by Rebecca Skloot ISBN-13978-0330533447
- Discussions on original research articles on model systems (in vitro, in vivo and other organisms) for studying cancers, aging and its prevalence in the animal and plant kingdom
 - Discussion on Nobel prize winning lectures and notes as available on nobelprize.org. Some of the noteworthy ones being
 - a. The Nobel Prize in Physiology or Medicine 1966 to Peyton Rous "for his discovery of tumour-inducing viruses" and Charles Brenton Huggins "for his discoveries concerning hormonal treatment of prostatic cancer"
 - b. The Nobel Prize in Physiology or Medicine 1975 to Dulbecco, Temin and Baltimore on mechanisms of tumor viruses
 - c. J. Michael Bishop - Nobel Prize lecture on 8 December 1989
<https://youtu.be/CDv77rmzKR4?si=bMvhS4RodpZMws3m>
 - d. James P. Allison delivered the lecture "Immune Checkpoint Blockade in Cancer Therapy: New insights, opportunities, and prospects for cures"
<https://www.youtube.com/live/siHiM-PBTJ8?si=QMPHUGtAYXI7JqXH>
 - Discussion on individual contribution of 2019 The Nobel Prize in Physiology or Medicine on The von Hippel-Lindau Tumor Suppressor Gene: Insights into Oxygen Sensing and Cancer by William G. Kaelin Jr., Sir Peter J. Ratcliffe, and Gregg L. Semenza
 - Discussions on seminal papers as well as current research papers related to the theoretical concepts

Essential reading:

1. The Biology of Cancer (Unit II, III, IV)	Robert A. Weinberg (Ed.)	Garland Sciences
2. Hallmarks of cancer (Unit II, III)	Hanahan and Weinberg	Cell, Cell Press 2011 https://doi.org/10.1016/j.cell.2011.02.013
3. The hallmarks of cancer (Unit II, III)	Hanahan and Weinberg	Cell. Cell Press 2000 https://doi.org/10.1016/S0092-8674(00)81683-9

Suggested reading:

1. The Molecular Biology of Cancer (Unit I, II, III)	Pelengaris S, Khan M (Eds.)	Blackwell Publishing, Oxford
2. The Genetic Basis of Human Cancer (Unit I, II, III)	Vogelstein & Kinzler	McGraw-Hill
3. Review and research articles as suggested in class (Unit IV)		

DSE-GEN-406

Molecular Plant-Microbe Interaction

Course Objective:

Pathogenic microbes are a global threat not only to human health but also to food production and quality. With the ever-increasing demand to improve agricultural yields and keep up with global food demand, this area of host–microbe interaction is becoming increasingly important for sustainable agriculture. The interactions between microbes and plants provide fascinating examples of biological communication. The course is designed to understand the molecular intricacies underlying host–pathogen relationships and to apply these insights to develop sustainable strategies for enhanced disease resistance in crops.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-406 Molecular Plant-Microbe Interaction	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Introduction and Experimental methods used in plant pathology and biocontrol	10
II	Microbial pathogenicity: molecular basis and evolution	15
III	Plant defence mechanisms: Molecular interactions and cross-talks	15
IV	Deploying Disease resistance strategies for sustainable agriculture	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing ‘Molecular plant-microbe interactions’, the students would have:

- Developed a foundational understanding of plant–microbe interactions and their importance for plant health and sustainable crop production.
- Gained insight into the molecular basis and evolution of microbial pathogenicity
- Understood the key components of plant defence systems and the complex molecular cross-talk involved in immunity.
- Learned how plants distinguish between pathogenic and beneficial microbes at the molecular and cellular levels.

- Acquired an appreciation of emerging disease resistance strategies and biotechnological approaches for sustainable agriculture.

Content (Theory)

45 hours

- I. **Introduction to plant-microbe interaction** (10 hours)
 - A historical perspective on the significance of plant health and current challenges to sustainable crop production, including beneficial microbes.
 - Introduction to central concepts underlying host-microbe interactions- pathogenic and symbiotic interactions
 - Genomic tools, molecular and cellular genetics, imaging for bacteria, fungi and oomycetes
- II. **Microbial pathogenicity: Molecular basis and evolution** (15 hours)
 - Pathogenesis concepts and definition, Molecular determinants of bacterial and fungal pathogenicity: effectors, elicitors, plant cell wall-degrading enzymes, host-specific toxins, host non-specific toxins, small RNA.
 - Beneficial microbes
- III. **Plant defence mechanisms: Molecular interactions and cross-talks** (15 hours)
 - Non-host resistance, Plant innate immunity, Pre-formed inhibitors of pathogen invasion
 - R genes (quantitative and monogenic resistance)
 - Guards and Decoys
 - Role of mobile small RNAs
 - Systemic acquired resistance.
 - How do plants differentiate good microbes from the bad guys
- IV. **Emerging Disease resistance strategies for sustainable agriculture** (5 hours)
 - Translational research advances and potentials:
 - Application of biotechnological tools, including genomics (NGT), transcriptomics, molecular genetics, gene editing (e.g. CRISPR-Cas9), and gene silencing (PTGS, HIGS, etc.)
 - Application of microbes for improving plant health

Content (Tutorials)

15 hours

1. Addressing individual queries on class concepts
2. Discussing relevant video content exemplified by :
 - How plant immune systems protect them from disease by Prof Jonathan DG Jones, The Sainsbury Lab
<https://www.youtube.com/watch?v=uVd1CYZDhnU>
 - Understanding the amazing ways plants defend themselves through videos by Prof Sheng-Yang-He

[Sheng-Yang He \(Michigan State U. and HHMI\) 1: Introduction to Plant-Pathogen Interactions - YouTube](#)

[Sheng-Yang He \(Michigan State U. and HHMI\) 2: The effect of climate on plant disease](#)

- Strategies for resistance to plant virus diseases
<https://www.youtube.com/watch?v=B82UmkOAgd8>

Discussing the related review articles:

-The plant immune system: From discovery to deployment (2024) Cell, Volume 187, Issue 9, 2095 - 2116

- Pathogen perception and signalling in plant immunity,(2024) Plant cell 36: 1465-1481

- Pattern-recognition receptors are required for NLR-mediated plant immunity (2021) Nature Plants: 7, pages 382–383

- Receptor networks underpin plant immunity (2018) Science; 360: 6395, pp. 1300-1301

[DOI: 10.1126/science.aat2623](https://doi.org/10.1126/science.aat2623)

- Plant-Pathogen Effectors: Cellular Probes Interfering with Plant Defenses in Spatial and Temporal Manners (Annu Rev Phytopathol, 2016) 54:419-441.

- Action Mechanisms of Effectors in Plant-Pathogen Interaction. Int. J. Mol. Sci. 2022, 23, 6758. <https://doi.org/10.3390/ijms23126758>

-Susceptibility genes 101: How to be a good host Annual Review of Phytopathology (2014) 52:551–81.

Essential Readings

1. Plant Pathology (Unit I, II, III, IV)	Agrios GN	Academic Press
2. Recent Reviews and research paper		

Suggested Readings

1. Molecular Plant pathology (Unit I, II, III, IV)	Dickinson M	BIOS Scientific Press
2. Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions (Unit I, II, III, IV)	Jeng-Sheng HT	Kluwer Academic Publ.

SEMESTER 4; S3

DISCIPLINE SPECIFIC ELECTIVE

2Y-PG

DSE-GEN-407

Yeast Genetics

Course Objective: *The course is designed to provide some fundamental principles on which to form an integrated view of various genetic and molecular processes using yeast as a model system. Tutorials would be in the form of discussion based on primary literature available related to each topic, highlighting the advances in each field.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-407 Yeast Genetics	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	The Yeast Genome and Functional Genomics	10
II	Mitochondrial Biology and Nuclear–Mitochondrial Communication	15
III	Nutrient Sensing, Signaling, and Yeast Longevity	15
IV	Protein-Based Inheritance and Pathogenicity in Yeasts	5
Tutorials		
	Various modalities as given below	15

Course outcomes : On completing 'Yeast Genetics', the students would have:

- Developed a clear understanding of the yeast genome as a model system and its significance in modern genetics and cell biology.
- Gained insight into genome-wide approaches of the post-genomic era for studying gene function and cellular organization.
- Understood the principles of mitochondrial structure and dynamics and their regulation within the cell.
- Learned how mitochondrial function and gene expression are coordinated with the nuclear genome.
- Acquired the ability to integrate genomic and mitochondrial processes to explain cellular adaptation and signaling.

Content (Theory)**45 hours****I. The Yeast Genome and Functional Genomics (10 hours)**

- Structure and organization of the yeast genome
- overview of life processes
- life with 6000 genes
- Advances in the post-genomic era :genome-wide microarray analysis, proteomics, and global protein localization studies.
- Functional genomics approaches : synthetic gene array analysis and large-scale genome engineering projects including SC2.0.

II. Mitochondrial Biology and Nuclear–Mitochondrial Communication (15 hours)

- Mitochondrial physiology in yeast
- Organelle dynamics, fusion and fission processes.
- Regulation of mitochondrial function by the nuclear genome
- mechanisms of mitochondrial gene expression
- Retrograde signaling pathways
- coordination between mitochondrial activity and nuclear gene expression.

III. Nutrient Sensing, Signaling, and Yeast Longevity (15 hours)

- Concepts of chronological and replicative life span in yeast
- Effects of environmental and nutritional cues, including calorie restriction and amino acid starvation, on cellular longevity
- Nutrient-dependent signaling pathways such as TOR signaling
- transcriptional regulation mediated by GCN4.

IV. Protein-Based Inheritance and Pathogenicity in Yeasts

- Prions in yeast as epigenetic elements,
- inheritance patterns, propagation mechanisms, de novo formation, structural features, and biological consequences of prions
- Overview of pathogenic yeasts and associated diseases, with an introduction to *Candida albicans*.
- Comparative analysis of *Saccharomyces cerevisiae* and *Candida albicans* focusing on mating types, mitochondrial physiology, and carbon utilization strategies.

Content (Tutorials)**15 hours**

- Addressing individual queries on class concepts
- Discussing research papers on the power of budding yeast: The Yeast Genome and Functional Genomics
- The Power of Yeast <https://doi.org/10.1002/yea.70009>
- Nobel Yeast Research <https://doi.org/10.1093/femsyr/fow094>
- The art and design of genetic screens: yeast <https://doi.org/10.1038/35088500>
- Discussing research papers on Mitochondrial Biology and Nuclear–Mitochondrial Communication
- The Warburg and Crabtree effects: On the origin of cancer cell energy metabolism and of yeast glucose repression <https://doi.org/10.1016/j.bbabi.2010.08.010>
- Nucleus to Mitochondria: Lost in Transcription, Found in Translation <https://doi.org/10.1016/j.devcel.2016.06.003>
- Synchronized mitochondrial and cytosolic translation programs <https://doi.org/10.1038/nature18015>
- Discussing research papers on Nutrient Sensing, Signaling, and Yeast Longevity
- The power of yeast genetics applied to the powerhouse of the cell <https://doi.org/10.1016/j.tem.2014.12.002>

- Replicative and Chronological Aging in *Saccharomyces cerevisiae*
<http://dx.doi.org/10.1016/j.cmet.2012.06.002>
- Mitochondrial quality control during inheritance is associated with lifespan and mother–daughter age asymmetry in budding yeast <https://doi.org/10.1111/j.1474-9726.2011.00731.x>
- Mitochondrial anchorage and fusion contribute to mitochondrial inheritance and quality control in the budding yeast *Saccharomyces cerevisiae* <https://doi.org/10.1091/mbc.E15-07-0455>
- Discussing research papers on Protein-Based Inheritance and Pathogenicity in Yeasts
- Prions in Yeast <https://doi.org/10.1534/genetics.111.137760>
- Yeast Prions: Structure, Biology, and Prion-Handling Systems
<https://doi.org/10.1128/membr.00041-14>

Essential Readings

- | | | | |
|----|--|---------------------------|-------------------------|
| 1. | Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 (Unit I, II, III, IV) | Guthrie C & Fink GR(Eds.) | Elsevier Academic Press |
|----|--|---------------------------|-------------------------|

Suggested Readings

- | | | | |
|----|---|----------------------------------|-------------|
| 1. | Getting started with yeast, Methods Enzymol. Vol. 350, pp. 3-41 (2002) (Unit I, II) | Sherman F | |
| 2. | Yeast Research: A Historical Overview (Unit I, II, IV) | James A. Barnett & Linda Barnett | A S M Press |

GE-GEN-410

Basic Science to Biological Application

Course Objective:

The root of fascinating technological advances in biological science is in the basic science research with no inkling of future possibilities. Whether serendipitous or planned, this concept of blue sky research has contributed tremendously to advancement in science. This general elective aims to illuminate the students with the excitement of doing basic science research particularly in the light of their subsequent usage in biological application.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-410 Basic Science to Biological Application	4	3	1	0	B.Sc. in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Discoveries related to Nucleic acids	6
II	Discoveries related to Gene regulation	11
III	Discoveries related to cell biology	16
IV	Discoveries related to Protein Science	7
Tutorials		
Various modalities as given below		15

Course outcomes : On completing 'Basic Science to Biological Applications', the students would have:

- Developed an understanding of key discoveries in nucleic acid biology and how they transformed genome manipulation and functional analysis.
- Gained insight into major breakthroughs in gene regulation and molecular tools that enable controlled gene expression and interaction studies.
- Understood landmark discoveries in cell biology that led to modern plant transformation and biotechnological applications.
- Learned how advances in protein science have shaped structure prediction and functional analysis.
- Appreciated how foundational biological discoveries translate into real-world applications such as drug discovery therapeutic protein production and regenerative biology.

Content (Theory)

I. Discoveries related to Nucleic acids

- RNA interference
- Genome editing: CRISPER TALEN
- Transposon discovery to applications

II. Discoveries related to Gene regulation

- The regulatable promoter
- Yeast 2-hybrids
- Phage display (antibody) Gibson assembly
- Gateway cloning
- Yamanaka factors to stem cell reprogramming

III. Discoveries related to cell biology

- *Agrobacterium tumefaciens* mediated crown gal formation to plant transformation
- *Agrobacterium rhizogenes* mediated hairy roots to secondary metabolite production

IV. Discoveries related to Protein Science

- Crystallography to Alpha fold
- examples in Drug discovery applications
- Secretion pathway discovery to Insulin production

Content (Tutorial)

- **Addressing individual queries on class concepts**
- Discussing research papers on discoveries related to Nucleic acids
 - RNA Interference: Big Applause for Silencing in Stockholm
<https://doi.org/10.1016/j.cell.2006.12.001>
 - Introduction of a Chimeric Chalcone Synthase Gene into Petunia Results in Reversible Co-Suppression of Homologous Genes in trans
<https://doi.org/10.1105/tpc.2.4.279>
 - Flavonoid genes in petunia: addition of a limited number of gene copies may lead to a suppression of gene expression <https://doi.org/10.1105/tpc.2.4.291>
 - The new frontier of genome engineering with CRISPR-Cas9
<https://doi.org/10.1126/science.1258096>
- Discussing research papers on discoveries related to Gene regulation
 - Yeast Gal4: a transcriptional paradigm revisited
<https://doi.org/10.1038/sj.embor.7400679>
 - The evolution of the GALactose utilization pathway in budding yeasts
<https://doi.org/10.1016/j.tig.2021.08.013>
 - Studies on the positive regulatory gene, GAL4, in regulation of galactose catabolic enzymes in *Saccharomyces cerevisiae* https://doi.org/10.1007%2F978-1-4939-9861-6_16
 - GAL4 system in drosophila: A fly geneticist's swiss army knife
<https://doi.org/10.1002%2Fgene.10150>

- Separation of DNA Binding from the Transcription-Activating Function of a Eukaryotic Regulatory Protein <https://doi.org/10.1126/science.3080805>
- Discussing research papers on discoveries related to cell biology
 - Beyond My Wildest Expectations (A review by Eugene Nester regarding discovery of plant transformation) <https://doi.org/10.1146/annurev-micro-091313-103703>
 - Agrobacterium tumefaciens: From crown gall tumors to genetic transformation <https://doi.org/10.1016/j.pmpp.2011.06.004>
 - Agrobacterium tumefaciens: a Transformative Agent for Fundamental Insights into Host-Microbe Interactions, Genome Biology, Chemical Signaling, and Cell Biology <https://doi.org/10.1128/jb.00005-23>
- Discussing relevant video and popular blog content exemplified by
 - The CRISPR Apostle: Rodolphe Barrangou <https://www.youtube.com/watch?v=7qS2fjeVzsk>
 - Nobel winners Doudna, Charpentier discover how CRISPR Cas9 gene editing works <https://youtu.be/cuHD7jCY8X4>
 - Tinkering with Nature’s Tools: The CRISPR Pioneer Feng Zhang <https://youtu.be/x4o6IINr7pc>
 - Scientist Stories: Shinya Yamanaka, Cell reprogramming and Pioneering Induced Pluripotent Stem Cells <https://youtu.be/c5DxfxekDGk>
- Discussing relevant popular blog/content online exemplified by
 - Biographical Overview | Barbara McClintock - Profiles in Science <https://profiles.nlm.nih.gov/spotlight/l/>
 - Barbara McClintock and the Discovery of Jumping Genes (Transposons) <https://www.nature.com/scitable/topicpage/barbara-mcclintock-and-the-discovery-of-jumping-34083/>
 - Stem Cell Reprograming <https://iscrm.uw.edu/what-is-cell-reprogramming/>

Essential Reading

- | | | | |
|----|---|----------------------|----------------------------|
| 1. | The Gene: An Intimate History
(Unit I, II) | Siddhartha Mukherjee | Penguin Random House India |
|----|---|----------------------|----------------------------|

Suggested Readings

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|----|---|----------------------|------------------------------------|
| 1. | The Gene: An Intimate History
(Unit I, II) | Siddhartha Mukherjee | Penguin Random House India |
| 2. | The Song of the Cell: An Exploration of
Medicine and the New Human
(Unit III) | Siddhartha Mukherjee | Bodley Head |
| 3. | The Double Helix
(Unit 1, II, IV) | James D. Watson | Atheneum Publishers
in New York |
| 4. | Gene Machine
(Unit II, IV) | Venki Ramakrishnan | Basic Books |

SEMESTER 4; S3

SKILL BASED COURSE

2Y-PG

SBC-GEN-411

Scientific Writing and Presentation

Course Objective:

Scientific writing is a crucial skill for researchers, enabling them to communicate their findings effectively. This course is designed to help students develop a structured approach to writing research papers, reviews, and grant proposals. It will cover the essential components of scientific manuscripts, ethical considerations, and the nuances of publishing in reputed journals. Additionally, students will learn how to create impactful scientific presentations and posters. The course emphasizes clarity, coherence, and precision, ensuring that students can present their research in a compelling manner.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-411 Scientific Writing and Presentation	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		Teaching
I	Fundamentals	10
II	Ethics in scientific publishing and research	5
Practical		
I	Theory to practice -Short seminar presentation	15
II	Theory to practice -Designing scientific posters	15

Course outcome: At the end of the 'Scientific Writing and Presentation' course the students would have

- Understood the fundamental decision making of what to write under different sections of a scientific document
- Developed a strong understanding on good ethics to be implemented while writing a scientific document
- Recognized the importance of honest, impactful presentation of scientific content

Content (Theory)**15 hours****I. Fundamentals (10 hours)**

- Importance of scientific writing in research and academia
- Differences between scientific and general writing
- Common challenges faced by researchers in scientific communication
- Writing for different audiences: academia, industry, and the general public.
- Structure of scientific research papers
- Writing an effective abstract and selecting appropriate keywords
- Crafting a compelling introduction and research rationale
- Choosing a suitable title for maximum impact.
- Differences between research articles, narrative reviews, and systematic reviews
- Strategies for summarizing large volumes of literature
- Structuring a review article effectively
- Best practices for citation management and referencing.
- Components of a research proposal
- Writing a strong research rationale and hypothesis
- Budgeting and financial justification in grants
- Identifying funding opportunities and understanding the evaluation process.
- Designing impactful PowerPoint slides and scientific posters
- Techniques for delivering effective oral presentations
- Handling Q&A sessions confidently during conferences and thesis defenses
- Common mistakes to avoid in scientific presentations.

II. Ethics in scientific publishing and research (5 hours)

- Understanding plagiarism and ways to avoid it
- Criteria for authorship and handling conflicts of interest
- The peer-review process
- responding to reviewer comments
- Choosing the right journal and avoiding predatory publishers.

Content (Practical)**30 hours****I. Theory to practice -Short seminar presentation**

Students will be mentored and asked to make seminar presentations in the department

II. Theory to practice -Designing scientific posters

Students will be mentored and asked to make scientific posters to teach them responsible dissemination of scientific content and enthuse them towards 'science for society'

Essential readings

- | | | | |
|----|---|-----------------|-----------|
| 1. | The Craft of Scientific Writing
(Unit I, II) | Alley, M (2018) | Springer. |
|----|---|-----------------|-----------|
-

Suggested Readings:

- | | | | |
|----|--|-------------------------|----------------------------|
| 1. | The Craft of Scientific Writing
(Unit I, II) | Alley, M (2018) | Springer. |
| 2. | Science Research Writing: A Guide for
Non-Native Speakers of English.
(Unit I) | Glasman-Deal, H. (2010) | Imperial College
Press. |
| 3. | Writing Science: How to Write Papers
That Get Cited and Proposals That Get
Funded (Unit I, II) | Schimel, J. (2012) | Oxford University
Press |

SEMESTER 4; S3

RP-GEN-413-S3

2Y-PG

Research Project (Structure 3)

Course Objective: The objective of this **project work in Semester 3 and Semester 4 of Structure 3** is to provide hands-on experience to the students about handling a research problem. The students will be encouraged to design and carry out a small research project around a topic being investigated in the allotted lab under the supervision of the faculty member. The students are expected to present their objectives and experimental design before initiation of the experimental work. After completion, the students are expected to present their findings as a presentation and report in Semester 4, a continuation of their assigned work.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RP-GEN-412-S3 Research Project (Structure 3)	16	0	0	16	B.Sc in any branch of science	NA

Components of evaluation of research work		
Semester 3		
	Preparation and Presentation of Outline of Research Work	
	Internal assessment of mentor	
	Interim report submission & evaluation	
	Presentation and viva-voce	
Semester 4 (continued from Sem 3)		
	Internal assessment of mentor	
	Thesis submission & evaluation	
	Presentation and viva-voce	

Course outcomes : On completing 'Research Project', the students would have:

- Learnt how to inquire
- Acquired the ability to design their own experiments
- Acquired the skill to independently perform experiments
- Understood the importance of critical analysis and use of controls
- Developed the ability to trouble-shoot experiments
- Learnt to analyze data and present the work in written and presentation format

The student will carry out an independent piece of experimental work in the laboratory of an allotted supervisor. Supervisors for the project work will be based on draw of lots or as decided by the department. The students are expected to make two presentations, and submit a detailed report of the research work executed in one semester. The work will also be assessed on a continuous basis.