दिल्ली विश्वविद्यालय
University of Delhi

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CNC-II/093/1/EC-1282/26/5
Dated: 23.07.2026

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 4-1-6/ dated 29.04.2026)

Following addition be made to Annexure-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The syllabi of following Department under the Faculty of Inter-disciplinary and Applied Sciences based on Postgraduate Curriculum Framework 2024 are notified herewith for the information of all concerned:

DEPARTMENT	SYLLABI
Genetics	(i) 2 Year MSc.. Genetics Structure-I/II/III for Semester-III/IV - **Annexure-1**
Biophysics	(i) 2 Year M.Sc. Biophysics and Bioinformatics for Semester-III/IV- **Annexure-2**
Electronic Science	(i) 2 Year M.Sc. Electronics for Semester-III/IV–**Annexure-3**

REGISTRAR

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



DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS

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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

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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

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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

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Essential Reading

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

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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.

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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
    - Quantitative and qualitative analysis
    - Genotyping with (a) Microsatellite markers and (b) SNPs
    - 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**

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  - 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 tounderstand 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/

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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

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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

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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.

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- 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=x9IxJcnZMoA
  - How Technological Change Drives Improvement in Plant Breeding & Agriculture | https://www.youtube.com/watch?v=bbr1HPNmnF8
  - 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

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- 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 (1st 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 (2nd 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

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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.

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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

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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=aRWWIdz2YZc

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/nature 19057

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

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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.

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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=GPlvILKl5LE

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

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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)

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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

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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.

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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: Fst (definition, values); population-specific rare variants; genetic distance (Dij)
- Structure analysis: PCA (dimension reduction, genotype matrices, plots interpretation, clines/clusters); relation to Fst
- 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; S1 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.

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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
- Invitro 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)

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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

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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 *Drosophila* Genetics	**4**	**3**	**1**	**0**	**B.Sc. in any branch of science**	**NA**

Unit	Unit Name	Hours
Theory		
I	*Drosophila*: An indispensable organism for biomedical research	6
II	Molecular genetics of *Drosophila* gametogenesis and development	20
III	*Drosophila*-specific genetic toolkits for functional analysis of genes	10
IV	*Drosophila* 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.

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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.

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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, Larracuente 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

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- *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 *Drosophil*a - 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 *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
Drosophila Guide (Unit I)	Demerec& Kaufmann	Carnegie Press
D. melanogaster: 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
Drosophila: Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of *Drosophila* Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
Drosophila: A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

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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 *Dictyostelium*	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	*Dictyostelium* 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

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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**

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- **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_Kaksonen.mp4
  - Prestalk cells in slugs http://dictybase.org/Multimedia/morphogenesis/weijer1.avi

Essential Readings

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

Suggested Readings

1.	*Dictyostelium*, Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	Dictyostelium-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)		

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SEMESTER 4; S1 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.

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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

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- 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)		

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SEMESTER 4; S1 DISCIPLINE SPECIFIC ELECTIVE 2Y-PG

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.

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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

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- 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.

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SEMESTER 4; S1 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 filed.*

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.

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Content (Theory) **45 hours**

I. **The Yeast Genome and Functional Geno**mics (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.bbabio.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

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- 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/mmbr.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

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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	
Theory		Hours
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.

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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%2FBF00268616
  - 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

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- **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/ll
  - 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

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

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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

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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’

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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

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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	2nd Edition Oxford University Press
2.	Introduction to Genetic Analysis (Unit I, II, III, IV)	Griffiths A JF et al	12th 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; S2 DISCIPLINE SPECIFIC CORE 2Y-PG

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

SEMESTER 3; S2 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=x9IxJcnZMoA
  - How Technological Change Drives Improvement in Plant Breeding & Agriculture | https://www.youtube.com/watch?v=bbr1HPNmnF8
  - 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 (1st 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 (2nd 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=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=aRWWIdz2YZc

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/nature 19057

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=GPlvILKl5LE

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)		

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 *Drosophila* 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

SEMESTER 3; S2 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		
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: Fst (definition, values); population-specific rare variants; genetic distance (Dij)
- Structure analysis: PCA (dimension reduction, genotype matrices, plots interpretation, clines/clusters); relation to Fst
- 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
- Invitro 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; S2 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 *Drosophila* Genetics	**4**	**3**	**1**	**0**	**B.Sc. in any branch of science**	**NA**

Unit	Unit Name	Hours
Theory		
I	*Drosophila*: An indispensable organism for biomedical research	6
II	Molecular genetics of *Drosophila* gametogenesis and development	20
III	*Drosophila*-specific genetic toolkits for functional analysis of genes	10
IV	*Drosophila* 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, Larracuente 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 *Drosophil*a - 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 *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
Drosophila Guide (Unit I)	Demerec& Kaufmann	Carnegie Press
D. melanogaster: 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
Drosophila: Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of *Drosophila* Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
Drosophila: A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

SEMESTER 4; S2 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 *Dictyostelium*	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	*Dictyostelium* 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_Kaksonen.mp4
  - Prestalk cells in slugs http://dictybase.org/Multimedia/morphogenesis/weijer1.avi

Essential Readings

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

Suggested Readings

1.	*Dictyostelium*, Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	Dictyostelium-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; S2 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) **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)		

SEMESTER 4; S2 DISCIPLINE SPECIFIC ELECTIVE 2Y-PG

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 filed.*

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 Geno**mics (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.bbabio.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/mmbr.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; S2 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	
Theory		Hours
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%2FBF00268616
  - 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/ll
  - 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

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

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	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
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

SEMESTER 3; S3 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	2nd Edition Oxford University Press
2.	Introduction to Genetic Analysis (Unit I, II, III, IV)	Griffiths A JF et al	12th 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 tounderstand 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; S3 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=x9IxJcnZMoA
  - How Technological Change Drives Improvement in Plant Breeding & Agriculture | https://www.youtube.com/watch?v=bbr1HPNmnF8
  - 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 (1st 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 (2nd 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=aRWWIdz2YZc

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/nature 19057

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

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		
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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=7yIW0L9dLCQ
  - The age of genetic wonder | Juan Enriquez | TEDxCERN
  - https://www.youtube.com/watch?v=GPlvILKl5LE

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		
I	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 (7th 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

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 *Drosophila* 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

SEMESTER 4; S3 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 *Drosophila* Genetics	**4**	**3**	**1**	**0**	**B.Sc. in any branch of science**	**NA**

Unit	Unit Name	Hours
Theory		
I	*Drosophila*: An indispensable organism for biomedical research	6
II	Molecular genetics of *Drosophila* gametogenesis and development	20
III	*Drosophila*-specific genetic toolkits for functional analysis of genes	10
IV	*Drosophila* 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, Larracuente 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 *Drosophil*a - 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 *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III)	Bates & Arias	CSHL Press

Suggested readings

Developmental Biology (Unit II)	Gilbert SF	Sinauer Press
Development of *Drosophila melanogaster* (Vol. I & II) (Unit I, II, III, IV)	Bates & Arias	CSHL Press
Drosophila Guide (Unit I)	Demerec& Kaufmann	Carnegie Press
D. melanogaster: 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
Drosophila: Methods and Protocols (Unit III, IV)	Dahmann C	Humana Press
Fly Pushing: The Theory and Practice of *Drosophila* Genetics (Unit I, II, III)	Greenspan RJ	CSHL Press
Drosophila: A Practical Approach (Unit I, II, III)	Roberts DB	CSHL Press
Compiled reviews and research papers (Unit III, IV)		

SEMESTER 4; S3 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 *Dictyostelium*	8
II	Cellular organization and initiation of developmental process	9
III	Developmental processes and signaling pathways	20
IV	*Dictyostelium* 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_Kaksonen.mp4
  - Prestalk cells in slugs http://dictybase.org/Multimedia/morphogenesis/weijer1.avi

Essential Readings

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

Suggested Readings

1.	*Dictyostelium*, Evolution, Cell Biology, and the Development of Multicellularity (Unit I, II, III, IV)	Richard H Kessin	Cambridge University Press
2.	Dictyostelium-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) 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 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)		

SEMESTER 4; S3 DISCIPLINE SPECIFIC ELECTIVE 2Y-PG

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

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 filed.*

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 Geno**mics (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.bbabio.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/mmbr.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; S3 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	
Theory		Hours
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%2FBF00268616
  - 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/ll
  - 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

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

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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.

UNIVERSITY OF DELHI
MASTER OF SCIENCE (BIOPHYSICS AND BIOINFORMATICS)
based on
NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 06-Feb-2026 and in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 23-Feb-2026, and in the meeting of 'Standing Committee' held on 13-Mar-2026

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Department Highlights

The Department of Biophysics was established in 1984 and is part of the FIAS (Faculty of Interdisciplinary and Applied Sciences) at the University of Delhi South Campus. The department currently has five faculty members engaged in various research areas in Biophysics and Bioinformatics.

About the Program

The M.Sc. Biophysics and Bioinformatics program offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, hands-on practical and tutorials, dry and wet laboratory work, and dissertations.

Six categories of courses are being offered in this program: Discipline Specific Core Courses (DSC), Discipline Specific Elective Courses (DSE), Generic Elective Courses (GE), Skill Based courses (SB), Research methods/ tools/ writing courses under Research Track (RT), and Dissertation Research work. Students may opt for any Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences. The Core Courses, the Elective Courses and Generic Electives are four credit courses each. As per the University guidelines, the student is required to accumulate twenty-two credits each semester, a total of eighty-eight credits, to fulfill the requirements for a Master of Science (PG) degree in Biophysics and Bioinformatics.

The M.Sc. in Biophysics and Bioinformatics is an interdisciplinary program designed to bridge the gap between biology, physics, and computational sciences. The course integrates biophysical principles, molecular biology, computational biology, and bioinformatics to generate, interpret, and analyze large-scale biological datasets. The curriculum integrates theoretical knowledge with practical skills to train students in modern biophysics and bioinformatics, making them competent for careers in academia, healthcare, pharmaceuticals, and biotechnology industries.

Program Objectives (POs):

The program aims at equipping the students with advanced knowledge and skills in the area of biophysics and bioinformatics, such as to enable them to address present lacunae in biological systems understanding, with the following detailed objectives:

1. Foundational Knowledge in Biophysics & Bioinformatics

- Introduce students to fundamental principles of biophysics, molecular biology, bioinformatics, and computational biology.
- Provide a strong foundation in chemical, physical, and mathematical principles underlying biological processes.
- Equip students with knowledge of macromolecular interactions, protein structure, and cellular mechanisms.

2. Skill Development in Experimental and Computational Techniques

- Train students in molecular biology, genetic engineering, proteomics, and bioinformatics methodologies.
- Develop proficiency in computational biology tools, bioinformatics databases, and molecular modeling.
- Provide hands-on experience in biophysical techniques like spectroscopy, chromatography, and electrophoresis.
- Familiarize students with cell culture techniques and proteomics-based analytical methods.
- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).
- Develop skills in protein-protein interactions, and vaccine development.

3. Application of Biophysics and Bioinformatics in Research and Industry

- Enhance understanding of drug discovery, protein engineering, and genetic manipulation.
- Introduce applications of biophysics in disease modeling, structural biology, and vaccine development.
- Enable students to apply bioinformatics in genome sequencing, phylogenetic analysis, and personalized medicine.

4. Critical Thinking and Problem-Solving

- Encourage students to analyze and interpret biological data using statistical and computational approaches.
- Train students to design experiments for biomolecular research, drug development, and biomedical engineering.
- Develop skills in scientific communication, literature review, and data presentation.

5. Preparing for Advanced Research and Careers in Biotechnology & Healthcare

- Prepare students for careers in biotechnology, pharmaceuticals, computational biology, and academic research.
- Equip students with knowledge of current trends in biotherapeutics, vaccines, and bioenergetics.
- Provide exposure to ethical considerations, regulatory guidelines, and real-world applications in biosciences.

6. Genetic and Structural Insights into Biological Systems:

- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).
- Develop skills in protein-protein interactions, drug discovery, and vaccine development.

7. Application of Biophysical and Bioinformatics Approaches:
    - Bridge the gap between wet-lab experiments and computational biology.
    - Enable the integration of machine learning and AI-driven approaches for analyzing biological datasets.

Program Specific Outcomes (PSOs):

Upon successful completion of the M.Sc. in Biophysics and Bioinformatics, graduates will be well-equipped to contribute to the biotechnology and biological data analysis industries in the following areas:

1. Biotechnology Industry Contributions
- Drug Discovery & Development:
    - Apply computational modeling for drug design and screening.
    - Analyze protein-ligand interactions for pharmaceutical applications.
- Genetic Engineering & Synthetic Biology:
    - Utilize CRISPR, gene editing, and molecular cloning for therapeutic and agricultural advancements.
    - Engineer microbial and plant-based biofactories for biopharmaceuticals and industrial enzymes.
- Bioprocessing & Biomanufacturing:
    - Apply protein purification, expression optimization, and bioanalytical techniques in biopharmaceutical production.
    - Optimize fermentation and metabolic pathways using computational tools.
- Vaccine & Biotherapeutic Development:
    - Design rational vaccines and immunotherapies.
    - Conduct immune response modeling for personalized medicine.

2. Biological Data Science and Analysis
- Big Data Analytics in Life Sciences:
    - Analyze high-throughput genomic, transcriptomic, and proteomic datasets.
    - Use machine learning and AI for predictive modeling in personalized medicine.
- Computational Biology & Bioinformatics Tools:
    - Perform sequence alignment, phylogenetics, and structural modeling.
    - Develop and use databases for genomic and proteomic research.
- Systems Biology & Omics Data Integration:
    - Model biological networks for understanding disease mechanisms.
    - Integrate multi-omics data (genomics, transcriptomics, proteomics) for biomarker discovery.
- Statistical & Programming Skills for Biological Data Analysis:
    - Use R, Python, and bioinformatics pipelines for statistical inference.
    - Apply machine learning algorithms to classify biological patterns and anomalies.

About Program Structure

The M.Sc. Biophysics and Bioinformatics program is a two year program that is divided into four semesters. The program structure is based on the Post Graduate Curricular Framework (PGCF) under (New Education Policy) NEP-2020. The student is required to complete eighty-eight credits for the completion of the course and the award of a degree. The student has to accumulate twenty-two credits in each of the four semesters.

Under PGCF, during the first year of the program, the student is required to study mandatory six Discipline Specific Core courses (three DSC in each semester), and a total of four Discipline Specific Elective courses (two DSE in each semester). The student can also opt for 1GE from another sister department from FIAS instead, thus making this combination as 1DSE+1GE. In addition, the student will also be required to study 1 mandatory Skill based course (SBC) of 2 credits in each semester of the first year.

In the second year of the program, the student will choose any one of the two structures: Program Structure 1 (PG with only coursework), or Program Structure 2 (PG with coursework and research). Program structure 2 has a dissertation option that is continuous in both semesters. The Program Structure 3 (PG with research) is not being offered currently (as per the university guidelines). Both Structures- 1 and 2, require the student to complete two DSC in each semester. A student is expected to complete 3 DSE or 2DSE+GE combination in both semesters under structure-1. In Structure-2, a student has to opt for 2DSE or 1DSE+GE combination in both semesters along with a dissertation. Structure-1 also includes a 2 credit Skill based course in each semester. The details of the course credits and the courses available under each category of courses (DSC, DSE, GE, SB, RT) are elaborated in the tables ahead.

A minimum of 75% attendance in the practical and theory classes would be mandatory requirement for appearing in exams and obtaining the degree.

Course Credit Scheme

Program Structure-1: (PG with only coursework)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Program Structure-2: (PG with coursework + research)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Program Structure-3: (PG with research) (not being offered currently *)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**28**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-1 ***** *(a student can opt for either two DSE course, or one DSE with one GE)*

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC01: Biophysical Chemistry	3	0	1	4
BP-DSC02: Molecular Biology	3	0	1	4
BP-DSC03: Protein Sciences: Emerging Frontiers	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
BP-DSE02: Statistics and Programming for Life Sciences	3	0	1	4
BP-DSE03: Vaccines and Biotherapeutics	3	0	1	4
Generic Elective courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC01: Specialised Laboratory – I: Molecular Biology	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

#BP-DSE01 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-2 * *(a student can opt for either two DSE course, or one DSE with one GE)*

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC04: Computational Biology and Bioinformatics	3	0	1	4
BP-DSC05: Cellular Biophysics and Bioenergetics	3	0	1	4
BP-DSC06: Genetic Engineering	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
BP-DSE05: Biophysical methods: Fundamental Techniques	3	0	1	4
BP-DSE06: Text Mining Methods in Biology	3	0	1	4
Generic Elective courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC02: Specialised Laboratory – II: Cell Biology and Bioinformatics	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

#BP-DSE04 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Second Year: Program Structure -1 (PG with only coursework)

Semester-3 * *student can opt for either three DSE OR two DSE with one GE*

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC07: AI (Artificial Intelligence) in Drug Design	3	0	1	4
BP-DSC08: Physiological Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE07: Biophysical Methods: Frontiers	3	1	0	4
BP-DSE08: Biomolecular Interactions	3	0	1	4
BP-DSE09: Infection and Immunity	3	0	1	4
BP-DSE10: Protein Aggregation, misfolding and disorders	3	0	1	4
Generic Elective courses*				
#BP-DSE07 Biophysical Methods: Frontiers	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC03: Specialised Laboratory – III: Protein Chemistry	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
-	-	-	-	-
Total credits				22

#BP-DSE07 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Semester-4 **student can opt for either three DSE OR two DSE with one GE*

Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC09: High-Throughput Biology	3	0	1	4
BP-DSC10: Molecular Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE11: Algorithms in Computational Biology	3	1	0	4
BP-DSE12: Combating diseases: leveraging in-silico approaches	3	0	1	4
BP-DSE13: Protein Engineering and applications	3	0	1	4
BP-DSE14: Cellular and molecular neurophysiology	3	0	1	4
Generic Elective courses*				
#BP-DSE11: Algorithms in Computational Biology	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC-04: Specialised Laboratory – IV: Advanced Analytical Methods	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
-	-	-	-	-
Total credits				22

#BP-DSE11 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Second Year: Program Structure -2 (PG with Coursework and Research)

Semester-3 * *student can opt for either two DSE OR one DSE and one GE*

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC07: AI in Drug Design	3	0	1	4
BP-DSC08: Physiological Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE07: Biophysical Methods: Frontiers	3	1	0	4
BP-DSE08: Biomolecular Interactions	3	0	1	4
BP-DSE09: Infection and Immunity	3	0	1	4
BP-DSE10: Protein Aggregation, misfolding and disorders	3	0	1	4
Generic Elective courses*				
#BP-DSE07 Biophysical Methods: Frontiers	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Design Research Proposal	0	0	6	6
Total credits				22

#BP-DSE07 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Semester-4 * *student can opt for either two DSE OR one DSE and one GE*

Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC09: High Throughput Biology	3	0	1	4
BP-DSC10: Molecular Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE11: Algorithms in Computational Biology	3	1	0	4
BP-DSE12: Combating diseases: leveraging in-silico approaches	3	0	1	4
BP-DSE13: Protein Engineering and applications	3	0	1	4
BP-DSE14: Cellular and molecular neurophysiology	3	0	1	4
Generic Elective courses*				
#BP-DSE11: Algorithms in Computational Biology	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Analysis, Interpretation and Presentation	0	0	6	6
Total credits				22

#BP-DSE11 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

SEMESTER 3

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC07: AI (ARTIFICIAL INTELLIGENCE) IN DRUG DESIGN

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC07: AI (ARTIFICIAL INTELLIGENCE) IN DRUG DESIGN	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce the drug discovery pipeline and the role of AI, including data types and data-quality challenges.
- Explain machine learning and deep learning methods for target identification, molecular representation, protein structure analysis, and virtual screening.
- Explore generative AI and advanced AI approaches for de novo drug design, lead optimization, and critical evaluation of real-world applications.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Understand and analyze the AI-enabled drug discovery pipeline, including chemical and biological data types, data-quality challenges, and AI-based target identification approaches.
- Apply and compare machine learning, deep learning, and graph-based models for protein structure analysis, drug–target interaction modeling, virtual screening, and molecular property prediction.
- Evaluate advanced AI methods such as generative AI and multi-objective optimization for de novo drug design, lead optimization, ADMET prediction, and emerging real-world applications in drug discovery.

SYLLABUS OF BP-DSC-07

Theory component (45 hours)

Unit I: Drug Discovery Pipeline and the AI Revolution (6 hours)

Overview of the traditional drug discovery pipeline: target identification, lead discovery, lead optimization, preclinical and clinical stages; limitations of conventional experimental and computational approaches; emergence of AI in drug discovery post-2010 due to data explosion, high-dimensional chemical and biological spaces, and advances in computing power; overview of AI paradigms (machine learning, deep learning, generative AI) and their roles across different stages of the drug discovery process.

Essential Reading:

a) Paul, S. M. et al. How to improve R&D productivity: the pharmaceutical industry's grand challenge. Nature Reviews Drug Discovery (2010). 9(3):203-14. doi: 10.1038/nrd3078.
b) Schneider, G. Automating drug discovery. Nature Reviews Drug Discovery (2018).
c) Zhavoronkov, A. et al. Artificial intelligence for drug discovery, biomarker development, and generation of novel chemistry. Molecular Pharmaceutics (2019).
d) Vamathevan, J. et al. Applications of machine learning in drug discovery and development. Nature Reviews Drug Discovery (2019).

Unit II: Chemical and Biological Data Foundations for AI-assisted Drug Discovery (6 hours)

Types of data used in AI models: chemical representations (SMILES, molecular fingerprints, descriptors), protein sequences and structures, bioactivity and assay data, omics datasets, and phenotypic screening data; data curation, preprocessing, quality control, bias, and imbalance; challenges of sparse, noisy, and heterogeneous biological data; public databases, data integration, and data-sharing challenges; limitations of traditional molecular descriptors and motivation for learned representations.

Essential Readings:

a) Bajorath, J. Chemoinformatics and computational chemical biology. Journal of Chemical Information and Modeling (2014).
b) Wu, Z. et al. MoleculeNet: a benchmark for molecular machine learning. Chemical Science (2018).
c) Rifaioglu, A. S. et al. Recent applications of deep learning and machine intelligence on in silico drug discovery. Briefings in Bioinformatics (2019).
d) Kearnes, S. et al. Molecular graph convolutions: moving beyond fingerprints. Journal of Computer-Aided Molecular Design (2016).

Unit III: AI for Target Identification, Protein Structure, and Virtual Screening (20 hours)

AI-based target identification and validation: systems biology approaches, network and pathway analysis, disease gene prioritization, and integration of multi-omics data; case studies of AI-assisted target discovery.

AI for protein structure and drug–target interactions: conceptual overview of protein structure prediction, AI-assisted binding affinity prediction, structure-aware drug design, and protein–ligand interaction modeling.

Machine learning and deep learning for virtual screening: ligand-based and structure-based virtual screening, deep learning models for activity prediction, CNNs and graph-based molecular representations, advantages of AI over classical docking, and selected case studies.

Essential Readings:

a) Barabási, A.-L., Gulbahce, N., & Loscalzo, J. Network medicine: a network-based approach to human disease. Nature Reviews Genetics (2011).
b) Jumper, J. et al. Highly accurate protein structure prediction with AlphaFold. Nature (2021).
c) Yang, X. et al. Concepts of artificial intelligence for computer-assisted drug discovery. Chemical Reviews (2019).
d) Chen, H. et al. The rise of deep learning in drug discovery. Drug Discovery Today (2018).

Unit IV: Graph Neural Networks, Generative AI, and Lead Optimization (13 hours)

Molecules as graphs and molecular representation learning; graph-based representations and Graph Neural Networks (GNNs) for property prediction, toxicity assessment, and drug–target interaction prediction; applications in lead identification.

Generative AI for de novo drug design: chemical space exploration; generative models including VAEs, GANs, transformer-based architectures, and reinforcement learning for molecular optimization.

AI in lead optimization and ADMET prediction: optimization of potency, selectivity, and stability; AI models for ADMET, toxicity, pharmacokinetics, and bioavailability; multi-objective optimization and reducing late-stage drug attrition; illustrative case studies of AI-designed molecules.

Essential Readings:

a) Gilmer, J. et al. Neural message passing for quantum chemistry. International Conference on Machine Learning (ICML) (2017).
b) Duvenaud, D. et al. Convolutional networks on graphs for learning molecular fingerprints. NeurIPS (2015).
c) Gómez-Bombarelli, R. et al. Automatic chemical design using a data-driven continuous representation of molecules. ACS Central Science (2018).
d) Polykovskiy, D. et al. Molecular sets (MOSES): A benchmarking platform for molecular generation models. Frontiers in Pharmacology (2020).
e) Chen, R. et al. Artificial intelligence in ADMET prediction: current status and future perspectives. Drug Discovery Today (2020).

Practical component (30 hours)

1. Generation of molecular descriptors and fingerprints of a potential drug molecule.
2. To curate and clean bioactivity datasets and to build classical ML models for QSAR.
3. To identify potential disease targets using network analysis.
4. Comparison of docking vs ML-based predictions.
5. To implement a neural network for activity classification and property prediction.
6. To generate novel molecules using generative models.
7. To optimize compounds for activity and ADMET simultaneously.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC08: PHYSIOLOGICAL BIOPHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC08: PHYSIOLOGICAL BIOPHYSICS	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be able to enumerate the various processes & mechanisms controlling the physiological viability and function
- Students will understand the physical principles involved in physiological function of various organs and their sustenance.
- Students will understand the integration of principles of physiological functioning & sustenance at the whole body level.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should be able to design nutrition.
- Should be able to understand blood related disorders and recommend precautions.
- Should understand functioning of healthy muscles and diagnose muscle disorders.
- Should understand the functioning of the heart and recommend its healthy maintenance.
- Should be able to give recommendations for respiratory problems.
- Should understand the biophysical principles of the functioning of the kidney and its maintenance.
- Should understand the role of various hormones in animal & human bodies.

SYLLABUS OF BP-DSC-07

Theory component (45 hours)

UNIT I **(10 hours)**

Levels of structural organization and body systems, Homeostasis, Chemical level of organization, Cellular level of organization
Biophysics of Digestion: Overview of the Digestive System, Phases of Digestion, and Nutrition
Composition, function, and regulation of salivary, gastric, pancreatic, bile, and intestinal juices; Metabolism of Carbohydrates, Protein, Lipids
Biophysics of Respiration: Mechanisms and control of breathing; Transport of oxygen and carbon dioxide; Oxygen dissociation curves of haemoglobin and myoglobin, Bohr effect; Chloride shift; Human respiratory disorders

Essential readings:

a) Principles of Anatomy and Physiology with Study Guide by Gerard J. Tortora
b) Biophysics: A Physiological Approach by Professor Patrick F. Dillon (Author)

UNIT II **(20 hours)**

Biophysics of the circulatory system: Composition and function of blood and lymph, Blood pressure, capillary pressure, Regulation of blood pressure, Role of ionic balance. Blood groups and Rh factors, Blood coagulation, structure and function of haemoglobin, Sickle-cell anemia, thalassemia, and other disorders
Biophysics of Heart: Structure, origin, conduction, and regulation of heartbeat; Cardiac cycle; Electrocardiogram; Disorders of the heart; Atherosclerosis, arrhythmias.
Biophysics of Muscle Function: Ultra-structural, chemical, and physiological basis of skeletal muscle contraction: Molecular mechanisms in muscle contraction.

Essential readings:

a) Principles of Anatomy and Physiology with Study Guide by Gerard J. Tortora
b) Biophysics: A Physiological Approach by Professor Patrick F. Dillon (Author)

UNIT III **(10 hours)**

Structure and Function of the kidney: Physiology of urine formation; Role of the kidney in the regulation of water, salt, and acid-base balance, renal disorders, remedies; Biophysical perspective of the above.
Integration and Control: The endocrine system, hormones and other signalling molecules, hypothalamus, pituitary, parathyroid, adrenal, pancreas, and gonads; Other endocrine elements (pancreatic islets, etc.); Local chemical mediators, prostaglandins; Consequences of endocrine malfunction; Biophysical perspective of the above.

Essential readings:

a) Principles of Anatomy and Physiology with Study Guide by Gerard J. Tortora
b) Biophysics: A Physiological Approach by Professor Patrick F. Dillon (Author)

UNIT IV **(5 hours)**

Medical biophysics: Intermolecular Forces (Dipole, Polar and Nonpolar Molecules and Solubilities), Biophysics of Thermoregulation and Heat Exchange, Biophysical Principle for Biochemical Tests, Biomedical Telemetry (Biotelemetry), Patient Monitoring System, Radioactivity and ionizing radiation

Essential readings:

a) Medical Biophysics by Judit Fidy.

Practical component (30 hours)

- To prepare the blood film and identify the blood cells.
- To observe and count the lymphocytes in the blood.
- To isolate the lymphocytes from the blood.
- Effect of hypertonic/ hypotonic/isotonic on RBC membrane.

Suggested readings

Theory:

- **Books:** The latest editions of the following books are recommended:

1. Physiology, Biophysics, and Biomedical Engineering by Andrew W Wood (Taylor & Francis).
2. Textbook of Medical Physiology by Arthur C. Guyton (Elsevier Saunders).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE07: BIOPHYSICAL METHODS: FRONTIERS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE07: BIOPHYSICAL METHODS: FRONTIERS	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to delve deeper into biophysical methods and their applications in cutting-edge biological research. It emphasizes specialized and more sophisticated analytical techniques.
- Students would be provided an understanding of the historical development of these techniques and their current applications, advantages, and limitations.
- The student will be introduced to how these methods are used in modern biological research and biotechnology industry.
- The focus would be on data interpretation using these methods. The students will be motivated to analyze and discuss most appropriate methods for tackling unique research problems.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to apply advanced biophysical techniques for the study of complex biomolecules.
- The student will be able to understand the principles and applications of these methods.
- The students will be able to understand the design of experiments and analyse data for structural and functional analysis of biomolecular interactions.
- Student will be able to trace the history of development of these advanced techniques, making them aware of the advantages of the interdisciplinary approaches for solving complex biological problems. They will understand the current trends in biophysics and contribute to research in this field.

SYLLABUS OF BP-DSE-07

Theory component (45 hours)

UNIT I: Macromolecular Structure determination methods (10 hours)

- X-ray crystallography: History and development of X-ray crystallography, Principles of X-ray diffraction, Methods and Challenges in crystallizing biomolecules, Overview of data collection and refinement, Phase estimation through methods like Molecular replacement, Isomorphous replacement (MIR, SIR), Anamolous Dispersion (MAD, SAD), creating electron density maps, structure validation and model fitting. Introduction to Synchrotron sources. Cryo-crystallography, Advancements ex. SAXS.
- Nuclear Magnetic Resonance (NMR): Principles of 1D, 2D, 3D spectroscopy, chemical shifts and spin-spin interaction, Multidimensional NMR for protein and nucleic acid structure, Analysis of protein-ligand complexes and molecular movements.
- Electron Microscopy: Basics of cryo-EM, sample preparation, imaging, and data collection, Types (SEM, TEM), advantages and limitations of each, Combining cryo-EM and X-ray crystallography for structural determination

Essential reading:

a) Gale Rhodes (2006). Crystallography made crystal clear. Complimentary Science Series. ISBN: 0125870736
b) Bengt Nolting (2004). Methods in Modern Biophysics Springer India, ISBN: 9788181281173

UNIT II: Advances in Microscopic methods (12 hours)

- Introduction to Fluorescence microscopy: Principles, Fluorescent dyes, GFP constructs, design of experiments to study conformational changes in a model protein or nucleic acids, Monitoring binding interactions of a ligand to a protein.
- Atomic Force microscopy: Principles, topography, force spectroscopy, and imaging at the molecular level for measuring mechanical properties of biomolecules (e.g., protein-ligand interactions, DNA stretching), Force-distance curves and the study of biomolecular interactions, imaging of single-molecule conformations and surface-bound biomolecules.
- Optical Tweezers: Principles of optical tweezers, trapping and manipulating single molecules using laser beams, Measurement of force and displacement in molecular systems, Applications in studying protein unfolding, DNA/RNA mechanics, and molecular motors, Analysis of force-extension curves and thermodynamic parameters.

Essential reading:

a) Engelbert Buxbaum (2011) Biophysical Chemistry of Proteins: An Introduction to Laboratory Methods, Springer publishers ISBN 1441972501
b) Umakanta Tripathy (Editor) (2025) Biochemical and Biophysical Methods in Molecular and Cellular Biology, ISBN: 9819620872

UNIT III: Advances in Spectroscopic Methods (12 hours)

- Time resolved Spectroscopy: Overview of time-resolved absorption, fluorescence, CD, Raman techniques, Studying protein dynamics and conformational changes, Applications in enzyme kinetics, molecular mechanisms, inhibitory mechanism (competitive, non-competitive, or uncompetitive).
- Introduction to Dynamic Light scattering (DLS): Basic principles of light scattering, measuring protein size, conformational changes and heterogeneity of solution, applications in studying protein aggregation and stability
- Nanoparticle tracking Analysis (NTA): principle, method, and applications in biological context, Applications in clinical diagnostics and therapeutic industry
- Single Molecule analysis: Overview, Historical development, Impact on molecular biology, Advantages over ensemble-averaged techniques, Applications in studying biomolecular dynamics, folding, and interactions. Single-Molecule Fluorescence Spectroscopy (SmFRET): Overview, principle, experimental setup and data interpretations of Single-molecule fluorescence microscopy experiment for monitoring conformational changes and dynamic processes in real-time.

Essential reading:

a) Engelbert Buxbaum (2011) Biophysical Chemistry of Proteins: An Introduction to Laboratory Methods, Springer publishers ISBN 1441972501
b) Umakanta Tripathy (Editor) (2025) Biochemical and Biophysical Methods in Molecular and Cellular Biology, ISBN: 9819620872

UNIT IV: Advances in Protein-ligand interaction studies (11 hours)

- Surface Plasmon Resonance (SPR): Basics of SPR and its applications in studying biomolecular interactions, Interpretation of SPR sensograms, Measuring binding kinetics between proteins and ligands,
- Bio-Layer Inferometry (BLI): Overview, principle, method and working mechanism (light interference and reflection), types of sensors, and applications in biological research, use in combination with other techniques (e.g., mass spectrometry, SPR), High-throughput BLI for screening applications, and Temperature-dependent studies.
- Iso-thermal Calorimetry (ITC): Overview, principle and historical development, comparison and advantages with other biophysical techniques (e.g., surface plasmon resonance, fluorescence). Applications in studying protein-ligand binding, protein-protein interactions, and enzyme kinetics.

Essential reading:

a) Engelbert Buxbaum (2011) Biophysical Chemistry of Proteins: An Introduction to Laboratory Methods, Springer publishers ISBN 1441972501
b) Umakanta Tripathy (Editor) (2025) Biochemical and Biophysical Methods in Molecular and Cellular Biology, ISBN: 9819620872
c) Bengt Nolting (2004) Methods in Modern Biophysics Springer India, ISBN: 9788181281173

Tutorial component (15 hours)

UNIT I: Case studies related to each technique in published research papers will be discussed:

1. Understanding crystallographic data deposited in PDB and in papers, with special emphasis on case studies in protein-ligand interactions
2. Understanding data of AFM study of DNA-protein interactions in gene regulation.
3. Understanding the data and interpretation for cryo-EM in determining structures of large macromolecular complexes, and membrane proteins.
4. Understanding and analysing DLS data for interpreting heterogeneity of the sample.
5. Understanding and analysing NTA data for interpreting particles size and interactions.
6. Understanding the SPR data to analyse binding kinetics of protein-ligand interactions.
7. Understanding the BLI data to analyse binding kinetics of protein-ligand interactions.
8. Analyzing the raw data of ITC to determine thermodynamic parameters such as binding affinity (Kd), stoichiometry (n), enthalpy (ΔH), and entropy (ΔS).
9. Designing experiments for smFRET
10. Understanding use of optical tweezers to study the mechanical properties of DNA or protein folding

Suggested readings

- **Online Resources**:
  Instrumentation websites/Research Papers as discussed in class

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE08: BIOMOLECULAR INTERACTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE08: **BIOMOLECULAR INTERACTIONS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce the students to the essentials of Biomolecular interactions.
- The student will understand the structure of various biomolecules involved in various pathways of biological systems.
- They will be understand the interaction involve among biomolecules and its significance.
- The students will be delivered the knowledge about protein folding, denaturation and involvement of biomacromolecules among various pathological disorder

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to evaluate the structure of amino acid and protein.
- Student will be able to correlate the role of biomolecular interactions among biological pathways.
- Student will be able to comprehend how biomolecules folded and unfolded under various environmental conditions.
- Student will be able to study different processes involve the biomolecular interactions.
- Student will be able to describe the different pathological disorders involving biomolecules.
- Student will be able to learn the therapeutics involved in disorders

SYLLABUS OF BP-DSE08

Theory component (45 hours)

UNIT I **(20 hours)**

Journey from amino acid to protein: Introduction to amino acids, partial double bond character of peptide bond; structural levels of protein, posttranslational modifications of protein, techniques to study secondary tertiary and quaternary structure of protein, Greek key motifs, leucine zippers, determination of protein structure- Sequence determination of proteins, N- and C-terminal amino acid analysis; Edman's degradation: classical and automated procedures, DNA sequencing by Maxam and Gilbert method, Sanger's method.

Essential readings

a) Lehninger; Principles of Biochemistry; W.H Freeman and Company; 8th edition, 2022

b) T. A. Brown Gene Cloning & DNA Analysis An Introduction Seventh Edition, 2016, Wiley Black well

UNIT II **(10 hours)**

Role of Cooperativity in biomolecular interactions: cooperative and non-cooperative (Sigmoidal) binding of ligands, Hill equation, Sequential and concerted model for cooperative binding. Biomolecular denaturation process, study of molecules involved in the folding pathway of proteins, and Practical aspects of binding analyses.

Essential readings

a) J.M. Berg, J.L. Tymoczko and L. Stryer; Biochemistry; W.H. Freeman and Company. 8th edition, 2021

b) T Palmer, P L Bonner (2007) Enzymes, Biochemistry, Biotechnology, Clinical Chemistry, Second edition, Woodhead Publishing

c) Irwin H. Segel (1993) Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems, Second edition, Wiley

UNIT III **(5 hours)**

Biomolecular interactions of Protein/DNA/lipid/carbohydrate/drugs

Essential readings

a) Arun K. Shukla (2021) Biomolecular Interactions Part A and Part B: Elsevier Science

UNIT IV **(10 hours)**

Amyloid and functions: types of amyloids, techniques to study amyloids, factors affecting protein aggregation, aggregation kinetics, and therapeutic strategies to combat neurological disorders, pathological disorders induced by protein aggregates

Essential readings

a) David Eliezer (2016) Protein Amyloid Aggregation, Methods and Protocols, Humana Press

Practical component (30 hours)

UNIT I **(20 hours)**

Molten globule study of proteins (e.g., Lysozyme), electrophoresis of proteins, molecular docking study of protein-ligand interactions, Absorption spectrum of protein and DNA.

Essential readings

a) Wilson and Walker (2018) Principles and Techniques of Biochemistry and Molecular Biology, Eighth edition.

UNIT II **(10 hours)**

Secondary and tertiary structure study of protein, aggregation kinetics study of proteins, various assays to study aggregates

Essential readings

a) Emine Ercikan Abali (2021), Biochemistry, Lippincott Illustrated Reviews

Suggested readings

Theory:

Unit I: J.M. Berg, J.L. Tymoczko and L. Stryer; Biochemistry; W.H. Freeman and Company.

Unit II: D. Whitford; Proteins, Structure and Function; John Wiley & Sons Ltd.

Unit III: Emine Ercikan Abali (2021), Biochemistry, Lippincott Illustrated Reviews

Unit IV: Simon F Campbell (2008) Protein Folding, Misfolding and Aggregation Classical Themes and Novel Approaches, RSC Publishing.

Practical:

Unit I: Freifelder, David Michael; Physical biochemistry: applications to biochemistry and molecular biology; W.H. Freeman and Company.

Unit II: David Sheehan (2009) PHYSICAL BIOCHEMISTRY: PRINCIPLES AND APPLICATIONS Second Edition,Wiley

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE09: INFECTION AND IMMUNITY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE09: **INFECTION AND IMMUNITY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students understand the basic concepts of infection establishment and immune activation by the host in response to such an insult.
- To make students understand the basic concepts of innate and adaptive immunity, host-pathogen interaction, and the concept of prevention of infections through vaccines.
- To make students learn the techniques used to perform research in the field of basic immunology, immunotechnology, and immunodiagnostics.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand the fundamental concepts of the human immune system and basic immunology.
- Students will be able to differentiate innate and adaptive immune systems, broadly describe how the immune systems mature in the host, and how they function in protecting the host from infections.
- Students will be able to describe the basic structures and functions of bacteria, viruses, and parasites and describe pathogenic mechanisms used by them that are important in the interaction with humans.
- Students will learn to use the information acquired during the course to hypothesize how the immune system can be used to fight pathogenic microorganisms and how antigens of pathogenic origin can be used to elicit a protective immune response against the pathogen.
- Students will become acquainted with the immunology lab techniques and immunoinformatic tools and will be able to use this knowledge for designing immunotherapeutic molecules.

SYLLABUS OF BP-DSE09

Theory component (45 hours)

UNIT I **(12 hours)**

Historic perspectives and introduction to immunology: History and scope of immunology; Types of Immunity – innate immunity, acquired immunity- natural, artificial, active and passive; Antigens, epitopes, immunogenicity, antigenicity; PAMPs, DAMPs; PRRs-toll like receptors, acute phase proteins; Myeloid and lymphoid lineage cells - granulocytes, dendritic cells, macrophages, T and B lymphocytes; Inflammatory response; Complement activation and regulation, Major Histocompatibility Complex; Primary and secondary lymphoid organs.

Introduction to infectious diseases: Definition of infectious diseases; Symptoms and signs of infection; Acute and chronic conditions; Microbial pathogens – bacteria, viruses, fungi, parasites, and non-microbial pathogen – prions; Direct and indirect person-person transmission; Animal-human transmission; Resolution of infections; Mechanisms of infection; Nomenclature of pathogens; Emerging infectious diseases.

Essential readings

a) Immunology, 6th edition, (2006), J. Kuby et al, W.H. Freeman and Company, New York. ISBN-13: 978-1429202114.
b) Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub.

UNIT II **(10 hours)**

Humoral and cell-mediated immunity: Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Ig genes organization; B-cell receptor; Immunoglobulin superfamily; Principles of cell signalling; Basis of self & non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell subsets; Cell-mediated immune responses, ADCC; Cytokines: properties, receptors and therapeutic uses; Antigen processing and presentation; Cell-cell co-operation; Hapten-carrier system.

Essential Readings

a) Murphy, K. and Weaver, C. (2016) Janeway's Immunobiology, Garland Science, New York.
b) Immunology, 8th edition, (2012), Male, D., Brostoff, J., Roth, D.B. and Roitt, I., Elseivier Sauders. ISBN-13: 978-0323080583.

UNIT III **(9 hours)**

Clinical immunology: Immunity to infection – bacteria, viral, fungal and parasitic infections; Hypersensitivity: Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of $CD4^+$ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology – tumor antigens, immune response to tumors and tumor evasion of the immune system; Cancer immunotherapy; Immunodeficiency – primary immunodeficiencies, acquired or secondary immunodeficiencies; Autoimmune disorder; Anaphylactic shock; Immunosenescence; Immune exhaustion in chronic viral infection; Immune tolerance; NK cells in chronic viral infection and malignancy. Antibody engineering – generation of monoclonal antibodies, hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Essential Readings

a) Delves, P.J., Martin, S.J., Burton, D.R., Roitt, I.M. (2017) Roitt's Essential Immunology.
b) Joanne M. Willey, Kathleen M. Sandman, Dorothy H. Wood, Prescott's Microbiology, 11th Edition, Published by McGraw-Hill Education, ISBN 978-1-260-21188-7.

UNIT IV **(14 hours)**

Immunological Techniques and Immunodiagnostics: Precipitation, agglutination and complement-mediated immune reactions; RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, biosensor assays; Lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, microarrays; Immunodiagnostics based on precipitation, agglutination, haemagglutination, complement fixation test (CFT), labelled assays and *in vivo* reactions.

Vaccinology: Active and passive immunization; Introduction to live, killed, attenuated, subunit vaccines, DNA and protein-based vaccines, plant-based vaccines; Peptide vaccines; Conjugate vaccines; Role and properties of adjuvants; Reverse vaccinology; Idiotypic vaccines and marker vaccines; Viral-like particles (VLPs); Dendritic cell based vaccines; Vaccine against cancer; T cell-based vaccine; Edible vaccine and therapeutic vaccine.

Essential Readings

a) Medical Laboratory Technology Methods and Interpretations Volume 1 and 2, 6th edition (2009), Ramnik Sood; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
b) Vaccinology: Principles and Practice, by Editors: W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies; Wiley Blackwell, 2012.

Practical component (30 hours)

Immunoinformatics

1. Epitope Identification & Mapping

B-cell Epitopes (Linear): BepiPred 3.0 (latest version using deep learning) and ABCpred.
B-cell Epitopes (Conformational/3D): DiscoTope 3.0 and ElliPro.
T-cell Epitopes (MHC-I/CTL): NetMHCpan 4.1 and NetCTL 1.2.
T-cell Epitopes (MHC-II/HTL): NetMHCIIpan 4.0 and the IEDB Consensus Method

2. Characterization of Antigenic Potential

Antigenicity Score: VaxiJen 2.0 (alignment-independent) and ANTIGENpro.
Cytokine Inducibility: IFNepitope (for IFN-gamma) and IL4pred.
MHC Binding Affinity: The IEDB Analysis Resource for calculating IC50 values and percentile ranks.

1. **Safety & Biocompatibility**

Allergenicity: AllerTOP v2.0, AllergenFP, and Allermatch.
Toxicity: ToxinPred and its updated versions for predicting peptide toxicity.
Human Homology: NCBI BLASTp used specifically to screen for similarities against the human proteome to prevent autoimmunity.

4. Physicochemical & Structural Stability

Physicochemical Properties: ExPASy for molecular weight, pI, and instability index.
Population Coverage: IEDB Population Coverage Tool to calculate the percentage of people who can respond to selected epitopes.
Receptor Docking: AutoDock Vina, PatchDock, and ClusPro for simulating antigen interactions with TLRs or MHC molecules.
Structural Modeling: AlphaFold2 or PEP-FOLD for predicting the 3D structure of the antigen or vaccine construct.

Essential Readings

a) Immunoinformatics (Methods in Molecular Biology, Vol 2131) edited by Namrata Tomar. March 2020, Third Edition, eBook ISBN 978-1-0716-0389-5.

Suggested Readings

Theory

- **Unit I**: Robbins and Cotran Pathologic Basis of Disease, 8th edition (2009), Vinay Kumar, Abul K. Abbas, Jon C. Aster, Nelson Fausto; Saunders Publishers, ISBN-13: 978-1416031215.

- **Unit II**: Immunology: An Introduction, 4 th edition, (1994), Tizard, I.R., Saunders College Publishing, Philadelphia. ISBN-13: 978-0030041983.
- Microbiology, 7th edition, (2008), Prescott, L., John Ii Harley, Donald A. Klein, McGraw Hill. ISBN-13: 978-0071102315.

- **Unit III**: An Introduction to Immunology, Immunochemistry and Immunobiology, 5th edition, (1988), Barrett, James T., Mosby Company, St. Louis. ISBN-13: 978-0801605307.

- **Unit IV**: Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.

Practical

- Immunoinformatics: Bioinformatic Strategies for Better Understanding of Immune Function: Novartis Foundation Symposium 254, October 2003, Print ISBN:9780470853566, Online ISBN:9780470090763.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE10: PROTEIN AGGREGATION, MISFOLDING AND DISORDERS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE10: **PROTEIN AGGREGATION, MISFOLDING AND DISORDERS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To deliver the knowledge about why protein misfold and disorders related to misfolding of protein and preventive strategies.
- The student will understand formation of aggregates.
- They will be understand the difference between aggregates structures and level of toxicity.
- The students will be delivered the knowledge about mechanism of aggregation and kinetic pathways of aggregation
- The students will be motivated to learn protein misfolding disorders.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to characterize the protein aggregates.
- Student will be able to analyse the assembly process involve in the protein misfolding.
- Student will be able to learn about factors responsible for the protein aggregation.
- Student will be able to study the various methods and protocols involve in the study of protein misfolding and also learn about the diagnostic and therapeutic against disorders

SYLLABUS OF BP-DSE10

Theory component (45 hours)

UNIT I **(20 hours)**

Protein aggregation and oligomerisation, types of aggregates, toxicity of aggregates and oligomers, Factors responsible for protein aggregation: pH, Temperature; Co-solvent; shear effect; mutation etc. ubiquitin-proteasome degradation.

Essential readings

a) Marina ramirez-alvarado, jeffery w. Kelly, christopher m. Dobson; protein misfolding diseases: Current and Emerging Principles and Therapies; John Wiley & Sons Ltd

UNIT II **(10 hours)**

Mechanism of protein aggregation, characterization of protein aggregates, kinetics of protein aggregation.

Essential readings

a) Simon F Campbell (2008) Protein Folding, Misfolding and Aggregation Classical Themes and Novel Approaches, RSC Publishing.

UNIT III **(5 hours)**

Functional amyloids, Principles of protein misfolding: oxidative stress, role of molecular chaperons, kinetic models of protein misfolding.

Essential readings

a) David Eliezer; Protein Amyloid Aggregation: Methods and Protocols; Humana Press.6.

UNIT IV **(10 hours)**

Protein misfolding disorders: Alzheimer's disease, Parkinson's disease, Prion disease, hutington disease, systemic amyloidosis, cystic fibrosis, Gaucher disese, cataract, etc., methods and protocols to study protein misfolding and aggregates, Diagnosis and therapeutic strategies.

Essential readings

a) Cláudio M. Gomes; Protein Misfolding Diseases: Methods and Protocols; Humana Press.

Practical component (30 hours)

UNIT I **(20 hours)**

Formation of aggregates by using different proteins and factors:
A. Thermally induced aggregation of bovine serum albumin.
B. pH and surfactant-induced aggregation of lysozyme.
C. effect of mechanical stress on the aggregation rate of protein.

Essential readings

a) Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

UNIT II **(10 hours)**

Characterization of aggregates: ThT dye binding assay, Congo red dye binding assay, hydrophobicity measurement by using 8-Anilino-1-naphthalenesulfonic acid (ANS) as an extrinsic fluorophore.

Essential readings

a) Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)

Suggested readings

Theory:

Unit I: Freifelder, David Michael; Physical biochemistry: applications to biochemistry and molecular biology; W.H. Freeman and Company.
Unit II: David Eliezer (2016) Protein Amyloid Aggregation, Methods and Protocols, Humana Press
Unit III: Simon F Campbell (2008) Protein Folding, Misfolding and Aggregation Classical Themes and Novel Approaches, RSC Publishing.
Unit IV: H. John Smith and Claire Simons (2019) Protein Misfolding in Neurodegenerative Diseases Mechanisms and Therapeutic Strategies, CRC Press

Practical:

Unit I: Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)
Unit II: Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SBC03: SPECIALISED LABORATORY – III: Protein Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-SBC03: **SPECIALISED LABORATORY – III: Protein Chemistry**	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide practical skills on basic microbiological techniques.
- To expose students to the microbiology lab environment, basic lab infrastructure, basic equipment handling, and safety guidelines.
- To develop skilled manpower capable of handling basic lab strains of bacteria e.g. *E. coli*, for future molecular biology and genetic engineering experiments.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to isolate, characterize, and identify common bacterial organisms.
- Students will be able to calculate/determine the bacterial load of different samples.
- Students will be able to perform antimicrobial sensitivity tests.
- Students will learn about preserving bacterial cultures of short and prolonged durations.

SYLLABUS OF BP-SBC03

Practical component (60 hours)

Unit I

1. Ammonium Sulphate precipitation of protein.
2. Turbidity measurement of lysozyme by UV-Vis absorption spectroscopy.
3. Rayleigh scattering measurement of lysozyme by Fluorescence spectroscopy.
4. Demonstration of dialysis of proteins.
5. Demonstration of concentrating protein through centrifugation.
6. Scattering correction experiment to validate the concentration estimation of protein by UV-Vis spectroscopy.
7. Bacterial cell lysis by sonication.
8. Estimation of protein concentration by colorimetric methods.
9. Agarose Gel Electrophoresis of nucleic acids.
10. SDS-PAGE of proteins.
11. Case study & Group Discussion: Design of project proposals using techniques studied.

Essential readings

a) Cappuccino, J. G., & Welsh, C. (2016). Microbiology: A Laboratory Manual. Benjamin-Cummings Publishing Company.
b) Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
c) Freifelder, David Michael; Physical biochemistry: applications to biochemistry and molecular biology; W.H. Freeman and Company.

Suggested readings

a) David Sheehan (2009) Physical Biochemistry: Principles And Applications Second Edition,Wiley
b) Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.
c) Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISSERTATION – BP-DISSERTATION: Dissertation: DESIGN RESEARCH PROPOSAL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DISSERTATION: **DISSERTATION: DESIGN RESEARCH PROPOSAL**	**6**	**0**	**0**	**6**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide skills to students in research problem design.
- To acquaint students with the methods and process of literature review for a scientific project.
- To develop skills in formulating research problems and identify methodologies required to address the problem statement chosen.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will have completed Research Problem Identification.
- Students will have completed Review of Literature.
- Students will have completed Research design formulation.
- Students will have commenced experiments, fieldwork, or similar tasks

SYLLABUS OF BP-DISSERTATION: Design Research Proposal (180 hours)

The dissertation will be based on the labs assigned to the students in Sem III

UNIT1:
Design of research proposal, experiments (understanding through virtual lab), acquisition of Data, Completion of Literature Review.

Essential/recommended readings

a) William Trochim, James P. Donnelly, Kanika Arora (2023) Research Methods: The Essential Knowledge Base, Cengage
b) Saccenti E, Furlan C. Ten simple rules to complete successfully a computational MSc thesis project. PLoS Comput Biol. 2025 Jan 28;21(1):e1012756. PMID: 39874385
c) Berezin CT, Aguilera LU, Billerbeck S, Bourne PE, Densmore D, Freemont P, Gorochowski TE, Hernandez SI, Hillson NJ, King CR, KÃ¶pke M, Ma S, Miller KM, Moon TS, Moore JH, Munsky B, Myers CJ, Nicholas DA, Peccoud SJ, Zhou W, Peccoud J. Ten simple rules for managing laboratory information. PLoS Comput Biol. 2023 Dec 7;19(12):e1011652. PMID: 38060459
d) Oza VH, Whitlock JH, Wilk EJ, Uno-Antonison A, Wilk B, Gajapathy M, Howton TC, Trull A, Ianov L, Worthey EA, Lasseigne BN. Ten simple rules for using public biological data for your research. PLoS Comput Biol. 2023 Jan 5;19(1):e1010749. PMID: 36602970
e) Marai GE, Pinaud B, Bahler K, Lex A, Morris JH. Ten simple rules to create biological network figures for communication. PLoS Comput Biol. 2019 Sep 26;15(9):e1007244. PMID: 31557157.
f) Peterson TC, Kleppner SR, Botham CM. Ten simple rules for scientists: Improving your writing productivity. PLoS Comput Biol. 2018 Oct 4;14(10):e1006379. PMID: 30286072
g) Rougier NP, Droettboom M, Bourne PE. Ten simple rules for better figures. PLoS Comput Biol. 2014 Sep 11;10(9):e1003833 PMID: 25210732
h) Osborne JM, Bernabeu MO, Bruna M, Calderhead B, Cooper J, Dalchau N, Dunn SJ, Fletcher AG, Freeman R, Groen D, Knapp B, McInerny GJ, Mirams GR, Pitt-Francis J, Sengupta B, Wright DW, Yates CA, Gavaghan DJ, Emmott S, Deane C. Ten simple rules for effective computational research. PLoS Comput Biol. 2014 Mar 27;10(3):e1003506. PMID: 24675742
i) Zhang W. Ten simple rules for writing research papers. PLoS Comput Biol. 2014 Jan 30;10(1):e1003453. PMID: 24499936
j) Erren TC, Cullen P, Erren M, Bourne PE. Ten simple rules for doing your best research, according to Hamming. PLoS Compu**t** Biol. 2007 Oct;3(10):1839-40. PMID: 17967054

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER 4

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC09: HIGH-THROUGHPUT BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
BP-DSC09: HIGH-THROUGHPUT BIOLOGY	4	3	0	1	NIL	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- select the appropriate platform for system-level understanding of cellular phenomena
- critically assess the results of a proteomics, genomics and metabolomics experiment
- understand the merits/demerits of a analysis tool employed to analyze the results of proteomics, genomics and metabolomics experiment

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understanding of quantification and identification of proteins, their post-translational modifications and interactions from mass spectrometry data.
- Knowledge of commonly used technologies and bioinformatics principles for high-throughput genomics analysis.
- Know important biological databases and relevant statistics/ bioinformatics software tools to analyze microarray and NGS transcriptomics data.
- Should evaluate and apply the appropriate experimental design in a given metabolomics research question (including sample processing, choice of methods and analytical strategies).

SYLLABUS OF BP-DSC09

Theory component (45 hours)

UNIT – I **(6 hours)**

Mass spectrometry basics; Proteomics bioinformatics basics; Quantitative proteomics; Introduction to data independent acquisition approaches; MS proteomics repositories; Introduction to proteogenomics; Protein interaction data resources. Current developments and recent progress.

Essential readings:

a) Introduction to computational proteomics (first edition). Golan Yona. ISBN: 978-0367452285

UNIT – II **(27 hours)**

Advantages and disadvantages of different generations of DNA sequencers. Application-specific changes in the sample preparation methods for DNASeq, RNASeq, ChIPSeq and Metagenomics, single cell genomics.

Overview of NGS data formats – FASTQ, Single-end, Paired-end, Mate-pair. Measure of sequence read quality – Phred score; Read pre-processing and quality check assessment tools – FASTQC and Trimmomatic respectively.

Algorithm of NGS read assembly, contigs, scaffolds, assembly quality assessment using N50, total length, no. of contigs/scaffolds; Overview of read mapping, tools for read mapping – BWA, Bowtie, and their output file formats – BAM, SAM, SAMtools (Biosynthetic Gene cluster analysis); assessment of quality of read alignment; SNP and Variant Calling - Personalized medicine; variant visualisation tools – IGV.

Different methods of transcriptomic study; Quality assessment and QC of RNAseq read sequence data; Transcript identification, *de-novo* vs referenced-based transcriptome assembly; Differential gene expression analysis, Alternative splicing analysis, Visualization, Functional profiling of differentially expressed genes; Single-cell RNA-seq, spatial transcriptomics

Essential readings:

a) Next-Generation DNA Sequencing Informatics (second edition). Stuart M. Brown (Editor). ISBN 978-1-621821-23-6
b) Algorithms for Next-Generation Sequencing (first edition). Wind-Kin Sung ISBN: 978-1466565500

UNIT – III **(6 hours)**

Introduction to metagenomics, Basic methods and techniques for metagenomics study, Quality control, Community taxonomic profiling, Community diversity, metagenomic reads assembly, Taxonomic binning, metatranscriptomics, Applications of metagenomics: metagenomics of the human microbiome, bio-prospecting novel genes, metagenomics for industrial bioproducts, metagenomics for bioremediation, plant-microbe interactions, metagenomics and ecosystems biology;

Essential readings:

a) Methods in Molecular Biology (2649)- Metagenomic data analysis. Suparna Mitra (editor). ISBN: 978-1-0716-3071-6

UNIT – IV **(6 hours)**

Metabolomics: Introduction of different tools for metabolic profiling; Different tools used for metabolic data and database analysis e.g. KEGG, BioCyc, MetExplore and Cytoscape;Current developments and recent progress.

Essential readings:

a) Methods in Molecular Biology (2649)- Metagenomic data analysis. Suparna Mitra (editor). ISBN: 978-1-0716-3071-6

Practical component (30 hours)

1) Retreival, analysis and annotation of proteomics data
2) Retrieving NGS data from data sources - SRA toolkit; Aspera connect.
3) Assessment of read sequence quality using FASTQC, pre-processing of reads using Trimmomatic, Assembly of reads into genome, Determination of assembly quality and functional annotation of genes

Essential Readings:

a) Bioinformatics and Functional Genomics (third edition). Jonathan Pevsner. ISBN: 978-1-118-58176-6
b) Proteomics Data Mining - Advanced Computational Methods for Bioengineers: With R and Bioconductor (first edition). Jamie Flux. ISBN: 979-8300370244

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC10: MOLECULAR BIOPHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC10: **MOLECULAR BIOPHYSICS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will understand the chemical structure of various macromolecules involved in propagation of life.
- Student will comprehend the influence of macromolecular three-dimensional structure on their function.
- Student will appreciate the relevance of physics e.g., thermodynamics, kinetics, and cooperatively to the function of biological macromolecules.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to appreciate the effect of various forces in shaping the molecular conformation.
- Student will be able to correlate the biomolecular structure to its specific functions.
- Student will be able to comprehend the role of biomolecular conformation in function.
- Student will be able to appreciate the effect of cooperativity in protein/enzyme function

SYLLABUS OF BP-DSC10

Theory component (45 hours)

UNIT I **(15 hours)**

Nature of Chemical bonds: Forces responsible for molecular conformation, e.g., Hydrogen bonds, ionic/electrostatic interactions, Van der Waals interaction, hydrophobic interaction, and stereo-chemical factors

Macromolecular Structure

a) Protein Structure: Amino acids, peptide bond, primary, secondary, tertiary, and quaternary structure of proteins, motifs and folds, super-secondary structures.

b) Nucleic acid Structure: nucleosides and nucleotides, RNA structure, DNA structure and conformation, polymorphism of DNA

c) Other Biological Polymers: polysaccharides, associations formed among different macromolecular types

Essential readings

a) Saad Tayyab & Amru Nasrulhaq Boyce (2006) A Journey from Amino Acids to Proteins, UM press

b) Lehninger; Principles of Biochemistry; W.H Freeman and Company; 8th edition, 2022

UNIT II **(10 hours)**

Parameters defining conformation of a macromolecular chain, strategies for calculating the probable conformational status of a macromolecule, Computer simulation of macromolecular conformation, membrane protein conformation, Supercoiling of bio-macromolecules: Linking, twisting and writhing, topoisomerases

Essential readings

a) Amit Kessel, Nir Ben-Tal, Chapman and Hall (2018) Introduction to Proteins: Structure, Function, and Motion, Second Edition, CRC Press

b) T E Creighton, (1997), Protein Structure: a Practical Approach, Second Edition, Oxford University Press.

UNIT III **(5 hours)**

Special Bio-Macromolecules: Metalloproteins, nucleoproteins, ribozymes, membrane proteins, chaperons & prions.

Essential readings

a) Molecular Biophysics: Structures and Dynamics by Michel Daune (Oxford Univ. Press)

UNIT IV **(15 hours)**

Cooperativity in bio-macromolecular interactions: the phenomenon of cooperativity, DNA and protein melting, allosteric enzymes, Non-equilibrium thermodynamics in Biology: Information and Entropy, Nonequilibrium Processes, Coupling of Fluxes, Coupling of Chemical Reactions, far-from-Equilibrium Molecular Processes

Essential readings

a) Palmer T L Bonner (2007) Enzymes, Biochemistry, Biotechnology, Clinical Chemistry, Second edition, Woodhead Publishing

Practical component (30 hours)

UNIT I **(20 hours)**

- Purification of protein by using ion-exchange chromatography.
- Purity check by SDS-PAGE.
- Chemical and pH denaturation of lysozyme.

Essential readings

a) Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

UNIT II **(10 hours)**

- Excitation and emission spectrum of lysozyme.
- Fluorescence quenching experiment of protein-ligand binding.

Essential readings

a) Freifelder, David Michael; Physical biochemistry : applications to biochemistry and molecular biology; W.H. Freeman and Company

Suggested readings:

Theory:

Unit I: Biophysics - An Introduction by Rodney Cotterill (Wiley)
Unit II: Molecular Biophysics: Structures and Dynamics by Michel Daune (Oxford Univ. Press)
Unit III: The Biophysical Chemistry of Nucleic Acids & Proteins by Thomas E. Creighton
(Helvetica Press)
Unit IV: The Physical and Chemical Basis of Molecular Biology by Thomas E. Creighton (Helvetica Press); Molecular Biophysics by MV Volkenstein (Academic press)

Practical:

Unit I: Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)
Unit II: Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE11: ALGORITHMS IN COMPUTATIONAL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE11: **ALGORITHMS IN COMPUTATIONAL BIOLOGY**	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce algorithmic and computational methods for biological data analysis.
- Apply classical and AI-based algorithms for sequence, genome, and protein analysis.
- Explore computational and AI-driven approaches for drug design and systems-level biology.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Apply biological, mathematical, statistical, and computational principles to analyze molecular, omics, and clinical data for solving complex biological and biomedical problems.
- Design, implement, and evaluate bioinformatics algorithms and computational tools, including sequence analysis, data integration, visualization, and machine learning–based approaches.
- Critically interpret scientific literature and data resources and communicate bioinformatics insights effectively to both specialist and non-specialist audiences.

SYLLABUS OF BP-DSE11

Theory component (45 hours)

Unit I: Introduction to Computational Biology and Algorithmic Thinking (10 hours)

Overview of biological data types (sequence, structure, network, omics); Algorithm design paradigms: dynamic programming, greedy methods, divide and conquer, graph algorithms; Complexity analysis and biological relevance.

Essential reading:

a) Gagniuc, P. A. (2021). *Algorithms in bioinformatics: Theory and implementation* (1st ed.). John Wiley & Sons. ISBN 978-1119697961.

Unit II: Algorithms for Sequence Alignment and Phylogeny (11 hours)

Pairwise sequence alignment using Needleman–Wunsch, Smith–Waterman; Index-based alignment with Burrows–Wheeler Transform (BWT) and FM-index; Progressive and consistency-based approaches of Multiple Sequence Alignment; Neighbour-Joining, Maximum Likelihood (RAxML, IQ-TREE), Bayesian algorithms for Phylogenetic reconstruction

Essential reading:

a) Gagniuc, P. A. (2021). *Algorithms in bioinformatics: Theory and implementation* (1st ed.). John Wiley & Sons. ISBN 978-1119697961.

Unit III: Algorithms for Genome Assembly and Annotation (12 hours)

Overlap–Layout–Consensus (OLC) and De Bruijn Graph algorithms; Hidden Markov Models and Neural networks for gene prediction; Transcript assembly, quantification and differential expression; Motif discovery with Gibbs Sampling and Expectation–Maximization; Leveraging AI/ML and Deep-learning methods for improving Genome Assembly and Annotation.

Essential reading:

a) Ye, S. Q. (Ed.). (2016). *Big data analysis for bioinformatics and biomedical discoveries* (1st ed.). Chapman & Hall/CRC. ISBN 978-1-4987-2452-4

Unit IV: Algorithms for Protein Structure Prediction and Drug Design (12 hours)

- **Protein Structure Prediction Algorithms:** Sequence–structure alignment algorithms for protein-structure modelling (profile–profile comparison, threading, fold recognition); *ab-initio* prediction algorithms based on energy minimisation, fragment assembly, and conformational search; deep learning–based architectures for end-to-end 3D structure prediction.
- **Molecular Docking Algorithms:** Search and scoring algorithms employing genetic algorithms, Monte Carlo sampling, simulated annealing, and gradient-based optimization for predicting ligand–receptor interactions.
- **Molecular Dynamics Algorithms:** Force field computation methods, numerical integration schemes, and enhanced sampling algorithms.

- **QSAR and Virtual Screening Algorithms:** Descriptor generation, feature extraction, and machine learning–based predictive modeling for activity prediction and similarity-based or deep-learning virtual screening.
- **Network Pharmacology and AI-driven Drug Discovery:** Graph-based algorithms for modeling drug–target interaction networks, multi-objective optimization methods, and reinforcement learning or generative deep learning frameworks for de novo molecule design.

Essential reading:

a) Algorithms in Structural Molecular Biology. Bruce R. Donald. (Donald, 2023) Edition Publisher, MIT Press, 2023 ISBN: 0262548798, 9780262548793
b) Leach, A. R. (2001). *Molecular Modelling: Principles and Applications* (2nd ed.). Prentice Hall / Pearson Education. ISBN 0-582-38210-6.
c) Haspel, N., Jagodzinski, F., & Molloy, K. (Eds.). (2022). *Algorithms and methods in structural bioinformatics* (1st ed.). Springer Cham. https://doi.org/10.1007/978-3-031-05914-8 ISBN 978-3-031-05913-1 (hardcover); ISBN 978-3-031-05916-2 (softcover).

Tutorial component (15 hours)

1. Exploration of biological data formats (FASTA, FASTQ, GFF/GTF, PDB) and basic sequence statistics using scripting.
2. Implementation of dynamic programming for global and local sequence alignment (Needleman–Wunsch and Smith–Waterman).
3. Read alignment using index-based methods (BWT / FM-index) and comparison with classical alignment approaches.
4. Multiple Sequence Alignment and phylogenetic tree construction using Neighbour-Joining and Maximum Likelihood methods.
5. Genome assembly using De Bruijn Graph–based methods and evaluation using standard assembly metrics.
6. Gene prediction and genome annotation using HMM-based and machine learning–based tools.
7. Transcriptome analysis: RNA-seq read mapping, transcript assembly, quantification, and differential expression analysis.
8. Protein structure prediction using homology modeling or deep learning–based structure prediction tools.
9. Protein–ligand molecular docking and molecular dynamics simulation with analysis of binding and stability.
10. QSAR modeling and virtual screening using molecular descriptors, machine learning, and basic network-based drug–target analysis.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE12: COMBATING DISEASES: LEVERAGING IN-SILICO APPROACHES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE12: **COMBATING DISEASES: LEVERGING IN-SILICO APPROACHES**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce students to classifications of diseases and their molecular basis with a focus on the use of in-silico methods to study these diseases.
- Students will learn to use computational tools that can be applied to uncover the genetic causes of diseases, identify potential biomarkers, and develop therapeutic strategies.
- The students will gain hands-on experience with publicly available data and apply in-silico methods to real-world disease data.
- The students will be motivated to critically assess scientific literature on in-silico methods in disease research.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to understand the molecular and genetic basis of diseases.
- The student will be able to apply in-silico methods, bioinformatics, and computational biology approaches to study diseases.
- The students will be able to analyze and interpret data from biological databases related to diseases.

SYLLABUS OF BP-DSE12

Theory component (45 hours)

UNIT – I

a. Introduction to Diseases (12 hours)

- Definition, prevalence, classification types.
- Overview of infectious, metabolic, genetic and life-style-related diseases.
- Overview of rare/orphan diseases.
- Current challenges in diagnosing and treating complex diseases.

b. Genetic Basis of Diseases

- Types of mutations involved, Genetic variants, and their identification.
- Role of epigenetics and gene regulation in disease manifestation.
- Techniques for rare disease gene discovery: exome sequencing, genome sequencing, and linkage analysis.

Essential Readings:

a) RUNGE M.S. (Author) (2006) Principles of molecular medicine. Humana Press. ISBN: 9781588292025

b) Jules J. Berman (2014). Rare Diseases and Orphan Drugs: Keys to Understanding and Treating the Common Diseases, Academic Press.

UNIT – II

a. Data sources and Biomedical databases (20 hours)

- Introduction to Disease Ontology and Phenotype Ontology
- Overview of public databases: OMIM, Orphanet, ClinVar,
- Genetic and Rare Diseases Information Center (GARD).

b. In-silico tools useful for studying Diseases

- Principles of Genone-wide association studies (GWAS), application in identifying genetic variants.
- Introduction to computational tools like PLINK, SNPedia, and HapMap for variant analysis.
- Identifying disease-causing mutations using SIFT, PolyPhen, CADD.

Essential Readings:

a) Jonathan Pevsner (2015) Bioinformatics and Functional Genomics, Wiley-Backwell ISBN: 1118581784

b) Alon Uri (2018) Introduction to systems biology, Boca Raton CRC Press, ISBN:9781498770903

UNIT – III Identifying Therapeutic targets and pathways (8 hours)

- Network analysis of biological pathways through KEGG, Reactome, and BioGRID.
- Understanding protein-protein interactions (PPIs) in the context of diseases, (STRING, BioGRID, and Reactome).
- Visualization of networks and Identifying key regulatory nodes as molecular targets.

Essential Readings:

- a) Jonathan Pevsner (2015) Bioinformatics and Functional Genomics, Wiley-Backwell ISBN: 1118581784

UNIT – IV Frontiers in Diseases research (5 hours)

- Drug repurposing through pathway analysis in disease studies.
- The role of big data in understanding diseases, Introduction to AI/ML techniques in disease diagnosis.
- The future of in-silico drug discovery for diseases and personalized medicine.

Essential Readings:

a) RUNGE M.S. (Author) (2006) Principles of molecular medicine. Humana Press. ISBN: 9781588292025

Practical component (30 hours)

UNIT I: Databases/Webservers for analysing the following:

1. Analyzing examples of disease mutations at the molecular level (e.g., Cystic fibrosis, Duchenne muscular dystrophy).
2. Accessing and analysing data present in OMIM
3. Accessing and analysing data present in Orphanet
4. Accessing and analysing data present in ClinVar
5. Accessing and analysing data present in the Genetic and Rare Diseases Information Center (GARD).
6. Learning to mine and use data from PLINK
7. Learning to mine and use data from HapMap
8. Learning to mine and use data from SIFT
9. Learning to mine and use data from CADD
10. Understanding and extracting information from databases like KEGG
11. Understanding and extracting information from databases like Reactome
12. Understanding and extracting information from databases like BioGRID
13. Case study: Structural analysis of a protein linked to a disease.
14. Case study: Pathway analysis through PPI networks for metabolic disorder.
15. Case study: Drug repurposing

Essential readings

- **Online Resources**:

1. Databases, as discussed in the practical component.
2. https://ojrd.biomedcentral.com/articles/10.1186/s13023-024-03286-8

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE13: PROTEIN ENGINEERING AND APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE13: **PROTEIN ENGINEERING AND APPLICATIONS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to give the students an in-depth understanding and the skills necessary for independent target selection and protein engineering to develop novel products for society, with problem-solving.
- Another objective is to show the steps necessary for performing such protein engineering for a biotechnology invention.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to analyze the structure of proteins with databases.
- They will be able to analyze and compare the amino acid sequences and structures of proteins and relate this information to function.
- Students will learn the function of individual amino acids and their influence on the solubility, structure, and function of proteins, and understand the major factors for protein folding.
- Students will be able to construct bacterial expression plasmids for natural and modified genes and analyze the DNA sequence of proteins for factors that can affect the expression and properties of the protein.
- Based on the above analysis, be able to construct modifications to change the protein's properties.

SYLLABUS OF BP-DSE13

Theory Component (45 hours)

UNIT I **(8 hours)**

Concepts of protein structure and stability: Introduction to protein engineering; Protein structure and function; Protein folding and misfolding; Protein activity-stability-flexibility relationships (enzymatic, thermodynamic and kinetic); Forces stabilizing proteins – van der Waals, electrostatic, hydrogen bonding, covalent and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Correlation between structural features governing protein specificity-and-affinity and biophysical parameters like – pH, temperature, ionic strength, amino acid sequence.

Essential readings:

a) Introduction to Proteins: Structure, Function, and Motion, Second Edition By Amit Kessel, Nir Ben-Tal, Chapman and Hall/CRC, 2018.
b) Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford University Press.

UNIT II **(8 hours)**

Protein engineering concepts, approaches, and applications: Structural features of thermostable, cryostable, and halotolerant proteins. Creation of novel or altered structural proteins, enzymes, antibodies, antigens, transporters, receptors, and transcription factors; Redesign of structure, function, stability, and aggregation; Creation of designer and chimeric/fusion proteins; Combinatorial approaches to protein engineering; Rational approaches to protein engineering; Applications: enzyme engineering, protein allostery, biocatalysis, enzyme immobilization, protein production, antibody therapeutics, natural product biosynthesis.

Essential Readings:

a) Molecular Biology and Biotechnology, Edited by Ralph Rapley, PDF ISBN: 978-1-83916-896-3, EPUB ISBN: 978-1-78801-939-2, 17 May 2021.
b) Recent reviews from *Nature Biotechnology, Protein Science, PNAS*.

UNIT III **(9 hours)**

Tools and methods: Recombinant DNA technology-based strategies; Constructs, vectors, strains, affinity fusion tags; Chemical modification strategies; Site-directed mutagenesis – PCR-based and primer extension methods, Use of labels; Heterologous protein expression; Protein purification approaches; Protein handling; Protein biochemical and physico-chemical characterization using - ELISA, BLI, far-UV and near-UV CD, Fluorescence spectroscopy, UV absorbance, ORD, FTIR. **Computational tools:** Molecular visualization (PyMOL, UCSF Chimera) molecular modelling, Ab initio protein structure prediction, molecular docking, molecular dynamics simulations, energy functions and scoring**.**

Essential readings:

a) Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
b) Recent reviews from *Nature Biotechnology, Protein Science, PNAS*.

UNIT IV **(8 hours)**

Protein Engineering- Combinatorial: Chemical mutagenesis; Error-prone PCR; Synthetic peptide combinatorial libraries; V_H-V_L combinatorial scFv libraries, Principles and applications of phage, ribosome, yeast and bacterial display; Module shuffling; Gene site saturation mutagenesis; Selection and screening approaches for folding and function - high throughput screening methodologies like GigaMetrix, High throughput microplate screens.

(12 hours)

Protein Engineering- Rational: Guided protein recombination; Domain fusion; Backbone Reversal; Global conservative mutagenesis; Excision of super-secondary structures; Substructure shuffling with symmetric structures; Surface reengineering; Disulphide bond introduction; Loop redesign; Active surface transplants between homologous beta-sheet proteins; Whole surface transplants; Enzyme active site transplants; Loop transplants on beta/alpha barrels; Site-directed mutagenesis for kinetic or thermodynamic stability; Protein core and surface electrostatics reengineering; Thermostability and cryostability engineering; Industrial/ Biotechnological/ Medical/ Pharmaceutical Applications.

Essential Readings:

a) Stefan Lutz, Uwe Theo Bornscheuer (Editors), Protein Engineering Handbook, 2008, Wiley VCH, ISBN-10: 352731850X; ISBN-13: 978-3527318506.
b) Mallorie N. Sheehan Protein Engineering: Design, Selection, and Applications, Nova Science Publishers, Inc. (2011).

Practical component (30 hours)

1. Selection of target proteins for engineering using various databases.
2. Identification of possible sites for mutagenesis, combining the literature information and molecular visualization of the structure of the target protein.
3. Generation of mutant sequences and model generation.
4. Validation of the models using the Ramachandran plot, using online software.
5. Structural comparison of the mutant protein models with the wild-type protein for selection of the stable mutant.
6. Molecular dynamic simulation studies with the mutant and wild-type proteins.
7. Molecular docking studies with the selected mutant(s) and the ligand for the prediction of the functional characteristics of the mutants.

Essential Readings:

a) Baxevanis, A. D., Bader, G. D., & Wishart, D. S. (Editors). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 4th Edition. Wiley-Blackwell, Hoboken, NJ, 2020. ISBN-13: 978-1119335580; ISBN-10: 1119335582.
b) Latest manuals, handbooks, and workflow guides available online for each tool.

Suggested readings:

Theory:

- **Unit I:** J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.
- **Unit II:** Jeffrey L. Cleland & Charles S. Craik (Eds), Protein Engineering: Principles and Practice, Wiley (1996).
- **Unit III:** Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press.
- **Unit IV:** Sheldon J. Park & Jennifer R. Cochran (Eds) Protein Engineering and Design, CRC Press (2009).

Practical:

- Lesk, A. M. Introduction to Bioinformatics. 5th Edition, Oxford University Press, Oxford/New York, 2019. ISBN-13: 978-0198794141; ISBN-10: 0198794142.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE14: CELLULAR AND MOLECULAR NEUROPHYSIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE14: **CELLULAR AND MOLECULAR NEUROPHYSIOLOGY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

● Students will be able to understand the physical principles involved in the functioning of the cell & organelle membranes, ion channels, receptors & cell signaling.

● Students will be able to understand the biophysical basis of the functioning of neurons & other brain cells, their electrical behavior & communication mechanisms.

● Students will be able to understand the biophysics of perception, cognition & memory formation and the related neuronal disorders.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should achieve conceptual understanding of the structure & function of biological membranes including ion channels, receptors & other components.
- Should understand the functioning of the nervous system, electrical behavior of neurons & other brain cells.
- Should be able to make a comparison between the functioning of the natural brain & artificial (computer) brain.
- Should understand the biophysical principle of learning & memory.
- Should understand newer mechanisms of learning.

SYLLABUS OF BP-DSE14

Theory component (45 hours)

Unit I **(8 hours)**

Overview of the Nervous System: Introduction to neurons; The Neuron Doctrine; Components and classification of neurons; Types of neurons; Cytology of neurons; Dendrites structure and function; Axons structure and functional aspects; Ultrastructure; Myelination and synapses. impregnation method; Structure and function of glial cells; Different types of glial cells: astrocytes, oligo dendrocytes and Schwann cells; Overview of glial and neuronal relationship in the CNS; Importance of astrocytes in glutamate metabolism and blood brain barrier; Microglial phenotypes; Glial –neuronal interplay in the CNS; Principles of fixation and staining of nervous tissue; Methods of tissue processing for microtomy and cryotomy.

Essential readings

a) Squire, Fundamental Neuroscience (4th Edition), Elsevier,2013
b) Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007

Unit II **(20 hours)**

Biophysical basis of Neurophysiology : **Electrical behavior of the biological membrane**: Model membranes; Biological membranes and Dynamics; Membrane Capacitance; Transport across cell and organelle membranes; Ion Channels; Experimental methods to study Ion Channels.

Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current-voltage relations; Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes; Membrane potential and role of sodium and potassium pumps

Neural Signals: Physicochemical principles; Resting potential; Action Potential; Membrane theory of action potential; Hodgkin-Huxley's (HH) model

Sensory Receptors and Perception.

Special Senses: Vision: Photochemistry of vision, Neural pathways of vision, accommodation, light & accommodation reflexes, modern concept of color vision,

Audition: Organ and Pathways of audition

Olfaction: Olfactory organ, olfactory transduction, pathways

Gustation: Gustatory organ, pathways, transduction.

Pathophysiological conditions related to Sensory system

Essential readings

a) The Structure of Biological Membranes by Philip L. Yeagle, (CRC Press).
b) Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill Livingstone, 2006
c) Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007

Unit III **(10 hours)**

Synaptic transmission & Neurotransmission Synaptic vesicles; Principles of synaptic transmission: Electrical and chemical synapses; Calcium hypothesis: Control of transmitter release; Synthesis and trafficking of neuronal proteins. Synaptic transmission at nerve-muscle synapses; Synaptic transmission at central synapses; Ligand-gated channels; Second messengers and synaptic transmission. Sodium/ potassium pump – Role of calcium. Chemical transmission

Essential readings

a) Kandel, Principles of Neural Science (5th edition), McGraw Hill,2013

Unit IV **(7 hours)**

Neurotransmitters & Neuromuscular Coordination Neurotransmitters – types, synthesis and secretion of neurotransmitters, Receptors–adrenergic receptors and cholinergic receptors. Regulation of transmission, Neurotoxins. Forces involved in ligand–receptor interaction, neuromuscular transmission, reflex action, and reflex arc. Regulation of body temperature. Interaction between sense organs and neurons. Artificial neurons; Neural Basis of Cognition and Behavior, Prediction of membrane protein types from sequences, voltage-sensing elements in any membrane protein.

Essential readings

a) Elements of. Molecular. Neurobiology. Third Edition. C. U. M. Smith. Copyright © 2002 John Wiley & Sons, Ltd

Practical component (30 hours)

- Basic concepts of microscopy, stereology, and image analysis; Principles and applications of confocal microscopy.
- Study of the nerve cell: cresyl violet staining.
- Study of permanent slides.
- Acquisition of data for various physiological parameters using various computational data acquisition systems.

Essential/Recommended readings

Theory:

Suggested Books:

The latest editions of the following books are recommended:

1. Neuroscience: A Mathematical Primer by Scott, A. (Springer)
2. Cognitive Neuroscience: The Biology of the Mind by Gazzaniga, M.S. et al. (W.W.Norton & Co)
3. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A. Tuszynski, (Springer Science & Business Media)
4. Methods in Membrane Lipids by Alex DoPico (Humana Press)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SBC04: SPECIALISED LABORATORY – IV: Advanced Analytical Methods

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-SBC04: **SPECIALISED LABORATORY- IV: Advanced Analytical Methods**	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide analytical skills of advanced protein related experiments.
- Student will be taught various types of chromatography for protein purification
- To expose students to the software related to analysis of analytical ultra-centrifugation

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to execute the affinity chromatography experiment.
- Students will be able to perform experiment of size exclusion chromatography.
- Students will be able to perform analysis by using software related to analytical ultra-centrifugation.

SYLLABUS OF BP-SBC04

Practical component (60 hours)

Unit I

1. Affinity purification of proteins (HIS-Tag).
2. Demonstration of Gel filtration.
3. Crystallization setup of proteins
4. Data analysis of Analytical Ultracentrifuge: SEDFIT software
5. Data analysis of Analytical Ultracentrifuge: SEDPHAT software
6. Data analysis of Analytical Ultracentrifuge: GUSSI software
7. Case study/Group Discussion of data analysis and results.

Essential readings

a) Schuck, P., Zhao, H., Brautigam, A. C., Ghirlando, R., BASIC PRINCIPLES OF ANALYTICAL ULTRACENTRIFUGATION. CRC Press.
b) Schuck, P., Zhao, H., SEDIMENTATION VELOCITY ANALYTICAL ULTRACENTRIFUGATION: Interacting Systems. CRC Press. Arnolds.
c) Freifelder, David Michael; PHYSICAL BIOCHEMISTRY : APPLICATIONS TO BIOCHEMISTRY AND MOLECULAR BIOLOGY; W.H. Freeman and Company.

Suggested readings:

a) David Sheehan; PHYSICAL BIOCHEMISTRY: PRINCIPLES AND APPLICATIONS; John Wiley & Sons Ltd
b) Freifelder, David Michael; Physical biochemistry: applications to biochemistry and molecular biology; W.H. Freeman and Company.
c) Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISSERTATION – BP-DISSERTATION: DISSERTATION: ANALYSIS, INTERPRETATION & PRESENTATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DISSERTATION: **DISSERTATION: ANALYSIS, INTERPRETATION & PRESENTATION**	**6**	**0**	**0**	**6**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to provide skills to students design experiments, analyse the results.
- To develop skills in tackling research problems and compiling their study as publishable material or product development.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will have completed Experimentation/fieldwork.
- Students will have completed the submission of the dissertation.
- Students will have completed a Research output in any of the 3 forms
    b) Prototype or product development/patent.
    c) Any other scholastic work as recommended by the BRS ad approved by Research Council
    d) Publication in a reputed Journals such as Scopus Indexed journals or other similar quality journals
    e) Book/book chapter in a publication by a reputed publisher

SYLLABUS OF BP-DISSERTATION: Analysis, Interpretation and Presentation

(180 hours)

The dissertation will be based on the labs assigned to the students in Sem III

UNIT1:
Analysis of data, interpretation and presentation of work

Essential/recommended readings

a) William Trochim, James P. Donnelly, Kanika Arora (2023) Research Methods: The Essential Knowledge Base, Cengage
b) Saccenti E, Furlan C. Ten simple rules to complete successfully a computational MSc thesis project. PLoS Comput Biol. 2025 Jan 28;21(1):e1012756. PMID: 39874385
c) Berezin CT, Aguilera LU, Billerbeck S, Bourne PE, Densmore D, Freemont P, Gorochowski TE, Hernandez SI, Hillson NJ, King CR, KÃ¶pke M, Ma S, Miller KM, Moon TS, Moore JH, Munsky B, Myers CJ, Nicholas DA, Peccoud SJ, Zhou W, Peccoud J. Ten simple rules for managing laboratory information. PLoS Comput Biol. 2023 Dec 7;19(12):e1011652. PMID: 38060459
d) Oza VH, Whitlock JH, Wilk EJ, Uno-Antonison A, Wilk B, Gajapathy M, Howton TC, Trull A, Ianov L, Worthey EA, Lasseigne BN. Ten simple rules for using public biological data for your research. PLoS Comput Biol. 2023 Jan 5;19(1):e1010749. PMID: 36602970
e) Marai GE, Pinaud B, Bahler K, Lex A, Morris JH. Ten simple rules to create biological network figures for communication. PLoS Comput Biol. 2019 Sep 26;15(9):e1007244. PMID: 31557157.
f) Peterson TC, Kleppner SR, Botham CM. Ten simple rules for scientists: Improving your writing productivity. PLoS Comput Biol. 2018 Oct 4;14(10):e1006379. PMID: 30286072
g) Rougier NP, Droettboom M, Bourne PE. Ten simple rules for better figures. PLoS Comput Biol. 2014 Sep 11;10(9):e1003833 PMID: 25210732
h) Osborne JM, Bernabeu MO, Bruna M, Calderhead B, Cooper J, Dalchau N, Dunn SJ, Fletcher AG, Freeman R, Groen D, Knapp B, McInerny GJ, Mirams GR, Pitt-Francis J, Sengupta B, Wright DW, Yates CA, Gavaghan DJ, Emmott S, Deane C. Ten simple rules for effective computational research. PLoS Comput Biol. 2014 Mar 27;10(3):e1003506. PMID: 24675742
i) Zhang W. Ten simple rules for writing research papers. PLoS Comput Biol. 2014 Jan 30;10(1):e1003453. PMID: 24499936
j) Erren TC, Cullen P, Erren M, Bourne PE. Ten simple rules for doing your best research, according to Hamming. PLoS Compu**t** Biol. 2007 Oct;3(10):1839-40. PMID: 17967054

The dissertation will be based on the labs assigned to the students in Sem III

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Annexure-3

UNIVERSITY OF DELHI

MASTER OF SCIENCE (ELECTRONICS)

based on

NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 17-02-2026, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 23-02-2026, and meeting of 'Standing Committee' held on _____

PROGRAMME BROCHURE



XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Historical Background of Department

The Department of Electronic Science was established in 1985 and is widely recognised as one of the most prestigious Electronic Science Departments in the country.

The Department is conducting courses leading to M.Tech. in Microwave Electronics and M.Sc. in Electronics. The aim of these programmes is to provide the necessary theoretical background and practical experience in order to meet the requirements of the R&D Organizations and Industries. In addition, the M.Tech. students work for 6 months on projects in collaboration with Industry and R&D Organisations and the M.Sc. students do in-house six months projects in the final semester. The curriculum of these courses is updated regularly to keep it in consonance with the changing industrial environment. Workshops/ seminars and hands-on workshops are organized on a regular basis to bridge the gap between academia and industry, and to provide requisite exposure to the students about the latest technological developments taking place in varied areas related to microelectronics, microwaves, communication, photonics etc. The interface with industry is further enhanced by an annual seminar under the Visitors' Programme in which professionals from industry, R&D organizations and academics are invited. Our alumni, now spread over a large number of government and private organisations, facilitate these interactions.

A full range of resources and facilities are available to the students. The Department has a wellequipped computer laboratory with various circuit simulation and microwave design software for students. In addition, there are well equipped laboratories for experimental work in the following areas: Microwave Measurements, Communication Electronics, Circuit Design, Electronic Materials and Semiconductor Devices, Microprocessors and Digital Signal Processing, Optical Electronics, Anechoic chamber and Microwave Component Fabrication. An assessment of students' performance is made through continuous series of tests and presentations in addition to semester end examinations to ensure highest standards.

The Department is actively helping the students in their placement through Campus interviews. Students graduating from the Department have found positions in both government and private organizations working in the areas of Semiconductors, Information Technology, Telecommunications, Defence and Space Applications, etc. The students graduating from the programs have the necessary theoretical and practical skills to take on any R&D and Production responsibilities in today's complex and challenging environment. This is evident from the contributions and achievements of our alumni in organizations like ST Microelectronics, Cadence, HFCL, Aricent, Transwitch, SAMEER, ISRO, Keysight Technologies, VVDN Technologies, DRDO laboratories like DEAL, LRDE and many more.

Department Highlights:

The Department is well established with thirteen faculty members. Extramural grants from DST, CSIR, DRDO, ISRO, etc as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department was also funded under the DST-FIST, UGC 12th plan and DUDST PURSE programs. The Department has well-equipped teaching and research laboratories with state-of-the-art equipment for fabrication, characterization and measurement in the areas of microwave measurement, electronic materials and semiconductor devices, communication electronics, photonics etc. A large number of TCAD and EDA tools are also available that further enhances and strengthens teaching and research. The students graduating from these programmes acquire the necessary theoretical and practical skills to take up roles in R&D organizations, academia as well as industry. Since the inception of these programmes, the Department has witnessed several success stories and our students have done exceptionally well and are placed in some of the most reputed government as well as private organizations such as SSPL, NPL, DEAL, IRDE, BEL, SAMEER, ISRO, Keysight technologies, VVDN Technologies, ST Microelectronics, cadence, NXP ARM, etc.

About the Program

The M.Sc. Electronics program offered by University of Delhi is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments. Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ techniques of research writing, and Dissertation/Problem based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester i.e. a total of eighty-eight credits over four semesters to fulfil the requirements for a Master of Science degree in Electronics (two-year program), and forty-four credits over two semesters to fulfil the requirements for a Master of Science degree in Electronics (one year *program).*

About Post-Graduate Attributes:

The curriculum is designed to train the students in basic and advanced areas of Electronics, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Electronics. This enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they undertake in their final year.

The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential electronics as well as the most recent advances in varied specialized areas. Thus, the program will prepare students for various opportunities in academia or industry, and equip them to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in varied areas of Electronics. Through the stimulus of scholarly progression and intellectual development, the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multidimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will gain requisite exposure in different branches of Electronics such as Microelectronics, RF & Microwaves, Communication and Photonics, Digital Signal Processing, Terahertz Technology etc. They will be able to design and execute experiments related to advanced Analog and Digital Circuits, Signal Processing, Embedded Systems, RF& Microwave Systems, and Optical Communication. They will also be able to execute a research projects in varied areas under supervision. The student will be equipped to take up a suitable position in academia or industry, and pursue a career in research if desired.

About Program Structure:

The M.Sc. Electronics program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020. Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement

course (SEC) in each semester of the first year. In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Structure-1: (PG with only coursework) (Level 6.5)

Sem	***Core courses***		***Elective courses***		***Skill based courses***		***Res Method courses***		***Dissertation/ Project***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2: (PG with coursework and research) (Level 6.5)

Sem	***Core courses***		***Elective courses***		***Skill based courses***		***Res Method courses***		***Dissertation/ Project***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3: (PG with research) (Level 6.5)

Sem	***Core courses***		***Elective courses***		***Skill based courses***		***Res Method courses***		***Dissertation/ Project***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. ELECTRONICS COURSE (NEP-PGCF)

Second-Year
Structure-1: (PG with only coursework)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Advanced Digital and Data Communication	3	1	0	4
DSC-08: Processing of Semiconducting Materials and Devices	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4
Generic Elective courses*				
GE-03: Science of Microwave Heating	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SBC-03: Software Defined Radio Techniques for Modern Wireless Systems	1	1	0	2
Total credits				22

*** (a student can opt for either three DSE courses, or two DSE with one GE)**

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-10: Advanced Digital Signal Processing	3	1	0	4
DSC-11: Principles of VLSI Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-14: Artificial Intelligence & Robotics	3	1	0	4
DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication	3	1	0	4

DSE-18: Modern Antennas	3	1	0	4
Generic Elective Courses*				
GE-04: Consumer Electronics	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SBC-04: Electronic Materials and Device Fabrication	1	1	0	2
Total credits				22

*** (a student can opt for either three DSE courses, or two DSE with one GE)**

Second-Year
Structure-2: (PG with coursework and Research)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Advanced Digital and Data Communication	3	1	0	4
DSC-08: Processing of Semiconducting Materials and Devices	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4
Generic Elective Courses*				
GE-03: Science of Microwave Heating	3	0	1	4
Dissertation/Academic Project/Entrepreneurship				6
Total credits				22

*** (a student can opt for either two DSE courses, or one DSE with one GE)**

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-10: Advanced Digital Signal Processing	3	1	0	4
DSC-11: Principles of VLSI Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-14: Artificial Intelligence & Robotics	3	1	0	4

DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication Systems	3	1	0	4
DSE-18: Modern Antennas	3	1	0	4
Generic Elective Courses*				
GE-04: Consumer Electronics	3	0	1	4
Dissertation/Academic Project/Entrepreneurship				6
Total credits				22

*** (a student can opt for either two DSE courses, or one DSE with one GE)**

Second-Year
Structure-3: (PG with only Research)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Emerging Materials and Technologies for Next-Generation Electronics	3	1	0	4
Discipline Specific Elective (DSE) courses **(a student can opt one DSE course from any of the research stream)**				
Credits in each course	Theory	Practical	Tutorial	Credits
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4

Stream A	**Stream B**	**Stream C**
Electronic Materials/ Semiconductor Devices & Circuits	**Meta-Materials/ Microwave/ Antennas**	**Communication/Signal Processing /AI&ML**
DSE-11 DSE-13	DSE-11 DSE-12	DSE-09 DSE-10 DSE-11

Research Methods/ Tools/ Writing				
RMT-01: Research Methodology and Practices	2	0	0	2
RMT-02: Tools for Research	2	0	0	2
One intensive research-based problem				10
Total credits				22

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline specific Elective (DSE) courses* **(a student can opt one DSE course from any of the research stream)**				
Credits in each course	Theory	Practical	Tutorial	Credits
DSE-14: Artificial Intelligence & Robotics	3	1	0	4
DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication Systems	3	1	0	4
DSE-18: Modern Antennas	3	1	0	4

Stream A	**Stream B**	**Stream C**
Electronic Materials/ Semiconductor Devices & Circuits	**Meta-Materials/ Microwave/ Antennas**	**Communication/Signal Processing /AI&ML**
DSE-15 DSE-16	DSE-15 DSE-18	DSE-14 DSE-17 DSE-18

Research Methods/ Tools/ Writing				
RMT-03: Techniques of Research Writing	2	0	0	2
One intensive research-based problem				16
Total credits				22

DISCIPLINE SPECIFIC CORE COURSE – DSC 07

Advanced Digital and Data Communication Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-07: Advanced Digital and Data Communication Systems	4	3	-	1	Entry level	Basics of Communication System.

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamental and modern concepts of analog and digital communication systems.
2. To learn the principles of information theory, source encoding, and error control coding.
3. To study multiplexing and multiple access techniques including OFDM and MIMO used in modern wireless systems.
4. To analyze the behavior of random variables and random processes in communication systems.
5. To understand the basics of data communication and networking protocols in wireless systems.

Learning Outcomes

At the end of this course, students will be able

1. Explain and compare analog and digital communication techniques.
2. Apply concepts of information theory and error correction coding in communication system design.
3. Describe multiplexing, OFDM, and MIMO techniques used in modern wireless standards.
4. Analyze and model communication systems using random processes and probability theory.
5. Demonstrate understanding of data communication fundamentals and wireless networking protocols.

SYLLABUS OF DSC-07 — Total Hours: 45h

UNIT -I (10 Lectures)

Random process and Random variables:

Probability and random variables; Baye's theorem; Probability density and probability distribution functions, statistical expectation, and characteristic functions, various continuous and discrete distributions, multiple random variables, transformation of PDFs; Random Processes, Classification of Random Processes, Power spectral density, Power spectrum of stochastic processes; Markov process.

UNIT – II (10 Lectures)

Introduction to Digital Modulation Transmitters:

Overview of digital transmitter architecture and signal flow, and principles and implementation of BPSK, QPSK, and QAM transmitters. Coherent Receivers for Digital Carrier Modulations, General Expression for Error Probability of optimum receivers. Information Theory: Measure of Information, Source Encoding, Entropy, Channel capacity, Error Correcting codes: Hamming code, linear block codes, cyclic codes, Huffman coding, Shannon-Fano coding, code tree & Trellis diagram.

UNIT – III (15 Lectures)

Multiplexing and Modern Communication Techniques:

Distortion less transmission Multiplexing: Frequency division Multiplexing, Time division Multiplexing, Multiplexing applications, Introduction to multiple access techniques, Spread Spectrum, Frequency Hopping in Bluetooth (IEEE 802.15), Code Division Multiple Access (CDMA). Introduction to Orthogonal Frequency Division Multiplexing (OFDM); Advantages and challenges of OFDM; OFDM Transmitter and Receiver Design, Serial-to-parallel conversion, Cyclic Prefix (CP); OFDM in Modern Wireless Standards, OFDM in Wi-Fi (IEEE 802.11x), OFDM in LTE and 5G/6G; MIMO Systems: Basic principles, spatial multiplexing, diversity gain.

UNIT – IV (10 Lectures)

Introduction to Data Communication and Networking:

Introduction to Data communication, Wireless protocols: IEEE 802.xx, Network layers; Routing, mobility management, Transport layer protocols for wireless networks; Types of transmission media: Guided Media, Unguided Media, Transmission Impairments, Circuit and packet switching.

List of Experiments: **30h**

1. To analyze a CDMA system and interpret the modulated and demodulated waveforms.
2. To analyze a Delta modulation-demodulation and observe effect of slope overload
3. To analyze a FSK modulation system and interpret the modulated and demodulated waveforms
4. To analyze a PSK modulation system and interpret the modulated and demodulated waveforms
5. To demonstrate Time Division Multiplexing and De-multiplexing process using Pulse amplitude modulation signals
6. To simulate Binary Amplitude shift keying technique using MATLAB software
7. To simulate Binary Frequency shift keying technique using MATLAB software
8. To simulate Binary Phase shift keying technique using MATLAB software
9. To simulate Quadrature Phase shift keying technique using MATLAB software
10. To simulate Differential Phase shift keying technique using MATLAB software
11. Study of single bit error detection and correction using Hamming code

Essential/recommended readings:

1. Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson. (Unit-II, and Unit-III)
2. Palaniammal, S. (2019). Probability and Random Processes. PHI. (Unit-I)
3. Lathi, B. P., & Ding, Z. (2019). Modern digital and analog communication systems, Oxford university press. (Unit-II, and Unit-III)

Reference Books:

1. Rappaport, T. S. (2024). *Wireless communications: principles and practice*. Cambridge University Press. (Unit III, and Unit IV)
2. Forouzan, B. A. (2007). *Data communications and networking*. Huga Media. (Unit-IV)
3. Montgomery, D. C., & Runger, G. C. (2020). *Applied statistics and probability for engineers*. John wiley & sons. (Unit-I)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 08

Processing of Semiconducting Materials and Devices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 08 Processing of Semiconducting Materials and Devices	4	3		1	Entry Level	Basics of Semiconductor Materials and Devices

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspect of semiconductor process technologies.
2. This course will create the foundation of Fabrication Techniques for Semiconductor Materials and Devices.
3. The course educates the students with the understanding science behind fabrication techniques of micro/nano electronic devices.
4. The main objective is to train the manpower/students in the field of semiconductor science and technology relevant to modern electronic industry/technology

Learning Outcomes

At the end of this course, students will be able

1. To understanding role of Semiconductor Devices in duality human life.
2. To ability to use vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
3. To skills over Device Isolation, Contacts and Metallization for CMOS Applications.
4. To trained with various processes and instruments to fabricate the electronic materials and devices.

SYLLABUS OF DSC-08 — Total Hours: 45 h

UNIT I: (10 Lectures)

Introduction:

Semiconductor Devices in Microelectronic Industry. Key concepts of Semiconductor Technologies: clean room specifications and safety requirements, Wafer cleaning processes, Semiconductor substrates processing technologies.

UNIT II: (13 Lectures)

Thin films and Pattern Transfer:

Key concepts of thin film deposition, High Vacuum and Ultra High vacuum Systems: thermal and e-beam evaporation, sputtering, MBE etc. Atomic layer deposition, Electrodeposition, Spray pyrolysis, Spin coating. Etching: Photoresists, Dry etching, Chemical etching, sputter etching, control of etch rate and selectivity, control of edge profile. Lithography: Optical, e-beam lithography, lift off, dip pen nanolithography. Micro/Nano fabrication on flexible substrates. Solution processes.

UNIT III: (12 Lectures)

Doping and Implantation of Semiconductors:

Doping: Fick's Diffusion Equation, Atomistic models of Diffusion, Analytic solutions of Fick's law, Diffusion Coefficients for common Dopants etc. Thermal Oxidation: The linear and parabolic coefficients, Effect of Dopants during Oxidation, Oxidation induced Stacking Fault, Alternative Gate Insulator for MOSFET applications. Ion Implantation: Coulomb Scattering, Channeling and lateral Projected Rang, Implantation Damage, Shadow junction formation, Buried Dielectrics etc. Rapid Thermal Processing: Thermoplastic Stress, Activation of Impurities, Processing of Dielectrics etc.

UNIT IV: (10 Lectures)

Device Isolation, Contacts and Metallization:

Junction and Oxidation Isolation, LOCOS Methods, Trench Isolation, Silicon-on-Insulator Isolation Techniques, Semi-insulating substrates, Schottky and Ohmic contacts, Alloyed Contacts, Multilevel Metallization, Planarization and advanced interconnects. CMOS Technologies.

List of Experiments: **30h**

1. To study the process of high vacuum creation in a bell jar system using vacuum pumps.
2. To remove of conducting ITO film from glass substrate by heating techniques.
3. Analysis/estimation of Lattice parameters of semiconductors from X-ray diffraction pattern.
4. To estimate the optical band gap of semiconductor thin film/nano structures absorption/reflection method.
5. Structural analysis of Semiconductors using FE-SEM/TEM characteristics images.
6. Wire boding techniques for Microelectronic Devices Integration (Case Studies).

Essential/recommended readings

1. G. S. May and S. M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley India, 2004 (Unit-I, and Unit-II)
2. M. J. Madou, *Fundamentals of Microfabrication*, 2nd Edition, CRC Press, 2011. (Unit-II, and Unit-III)
3. Stephen A. Campbell, Fabrication engineering at the micro-and nanoscale, 4th Edition, Oxford University Press, 2008. (Unit-I, Unit-II, and Unit-III)
4. Fundamentals of Device and Systems Packaging: Technologies and Applications by Rao R. Tummala, McGraw-Hill Publications (Unit-IV)

Reference Books:

1. Microelectronics Packaging Handbook by Rao R. Tummala, Eugene J. Rymaszewski, and Alan G. Klopfenstein
2. Robert F. Pierret, Semiconductor device fundamentals. Pearson Education India, 1996
3. Sunipa Roy, Solid State & Microelectronics Technology. Bentham Science Publishers, 2023

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

(Structure – III -Research Track)

DISCIPLINE SPECIFIC CORE COURSE – DSC 09

Emerging Materials and Technologies for Next-Generation Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-09: Emerging Materials and Technologies for Next-Generation Electronics	4	3	0	1	Entry level	Electronics

Learning Objectives

Students will learn to:

1. Analyze the unique physical and electrical properties of low-dimensional nanomaterials.
2. Investigate the design and simulation of electromagnetic metamaterials, focusing on S-parameter analysis.
3. Examine the architecture and operation of advanced transistor technologies.
4. To demonstrate the field of AI in the design of an electronic System and study the brain-inspired computing and quantum computing.

Learning Outcomes

At the end of this course, students will be able to

1. Evaluate and select specific nanomaterials and 2D structures for sensors and energy storage applications.
2. Design and characterize metasurfaces and Frequency Selective Surfaces
3. Assess the trade-offs between high-speed performance and low-power consumption in modern semiconductor nodes
4. Apply deep learning for the understanding of electronic phenomena and demonstrate brain-inspired computing and quantum computing.

SYLLABUS OF – DSC-09 (Research Track) Total Hours: 45h

UNIT -I (11 Lectures)

Nano-materials and Applications:

Properties of Nano-materials relevant to Electronics, Carbon Nanotubes (CNTs); 2D materials: Graphene, MXene, h-BN etc,; Transition Metal Dichalcogenides (TMDs); Metal Oxide nanoparticles; Quantum Dots; Nanowire; Applications: Optoelectronic Devices, Energy Storage, Sensors; Challenges and Future Directions.

UNIT -II (11 Lectures)

Metamaterials and their Applications:

Introduction of metamaterials, Split Ring Resonator (SRR); structure, and equivalent circuit, Double Negative (DNG) materials, propagation constant, permittivity, permeability, refractive index, boundary conditions, Unit Cell and its S-parameter analysis, Metasurfaces, Frequency Selective Surface (FSS), Polarization Convertor,

Microwave Absorber, Metalenses, Intelligent Reflecting Surfaces (IRS), Fabrication and testing of metamaterial and metasurfaces.

UNIT -III (12 Lectures)

Advanced Semiconductor Devices and Technologies

High-speed and low-power devices: Silicon-on-Insulator (SOI) technology; Fin Field-Effect Transistors (FinFETs); Gate-All-Around (GAA) FETs; Carbon Nanotube Field-Effect Transistors (CNTFETs); nanosheet FETs; High-k/Metal Gate (HKMG) technology; junctionless transistors. High-frequency and power devices: Gallium Nitride (GaN) High Electron Mobility Transistors (HEMTs)—design, working, and applications; Power MOSFETs; Heterojunction Bipolar Transistors (HBTs).

UNIT -IV (11 Lectures)

Large Language Model:

Machine Learning, Deep Machine Learning, and their scope in the fields of Electronics, AI, edge AI, and AI-aided Electronic design, Quantum Computing, and Neuromorphic Computing.

List of Experiments **30h**

1. Synthesis of Nanostructures by bottom to top approach.
2. Design and simulation of periodic structure and study of reflection phase and dispersion diagram of metamaterial unit cell.
3. Computation of permittivity and permeability of metamaterial unit cell.
4. Implement ML algorithm/Convolutional Neural Network (CNN) in MATLAB/Python.
5. Develop a Generative Adversarial Network (GAN) in MATLAB/Python.
6. Simulation of Spiking Neuron Model (LIF Model) in MATLAB/Python.
7. Implement Quantum Gates using IBM Quantum Experience.
8. To study and plot the Surface Potential and Subthreshold Characteristics of Non-classical Semiconductor device (MOSFET)
9. To study and plot the I-V and threshold voltage of MOSFET.

Essential/recommended readings

1. Michael F. Ashby, Paulo J. Ferreira and Danel L. Schodek, Nanomaterials Nanotechnologies and Design. An Introduction for Engineers and Architects, Published by Elsevier. (Unit-1, and Unit-2)
2. 2D Materials Fundamentals, Fabrication and Applications by Editors: Rekha Sharma, Sapna Raghav
3. Fundamentals of modern vlsi devices by Yuan Taur, Tak H. Ning, Cambridge University Press, 3rd Edition, 2021. (Unit-3)
4. Y. P. Tsividis, “Mixed Analog-digital VLSI Devices and Technology”, World Scientific Publishing Co Pte Ltd, 2002 (Unit-3)
5. Narain Arora, “MOSFET Models for VLSI Circuit Simulation: Theory and Practice” World Sintific, 2007. (Unit-3)
6. Elishai Ezra Tsur: Neuromorphic Engineering: The Scientists’, Algorithm Designers and Computer Architects’ Perspectives on Brain-Inspired Computing, CRC Press, 2022. (Unit-IV)
7. Amit Kumar Tyagi, Shrikant Tiwari, S. V. Nagaraj: Quantum Computing; The Future of Information Processing, CRC Press, 2025. (Unit-IV)

Suggested Readings/Books

1. C. Caloz, and T. Itoh, “Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications”, Hoboken, New Jersey: John Wiley & Sons Inc. 2006. (Unit-II).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 09

Advanced Driver Assistance Systems (ADAS)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE 09: Advanced Driver Assistance Systems (ADAS)	4	3	0	1	Entry level	Electromagnetic Theory

Learning Objectives

The Learning objectives of this course are as follows:

1. To provide an in-depth exploration of advanced automation application in the field of electronics.
2. To covers the fundamentals, design, and implementation of Advanced Driver Assistance Systems (ADAS).
3. To explores key technologies, sensors, algorithms, and the future of autonomous driving.
4. To fulfil the requirements of industries by providing knowledge of electronic sensors, and IoT.

Learning Outcomes

At the end of this course, students will be able to

1. Gain knowledge of ADAS, V2X, V2V, and V2I systems.
2. Understand the mechanism of all the components of ADAS.
3. Gain knowledge about sensor fusion and core functions of ADAS.
4. Develop the knowledge of machine learning and artificial intelligence in ADAS.

SYLLABUS OF DSE-09 Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to Advanced Driver Assistance Systems (ADAS):

Importance and Benefits of ADAS, Evolution of ADAS, Levels of Automation (SAE Levels 0–5), Regulatory and Safety Standards (NCAP, ISO 26262, etc.). Vehicle-to-Everything (V2X) Communication; Basics of V2X Technology, Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). Communication, Cybersecurity in V2X Networks. Autonomous Driving and Future Trends; Path Planning and Motion Control, Ethics and Challenges in Autonomous Vehicles, Trends in AI-Driven ADAS Development, Regulations and Future Roadmaps.

UNIT – II (10 Lectures)

Components of ADAS:

Cameras; Function, Types, Image Processing, Object Detection. Radar; Working Principles, Short-Range Radar, Long-Range Radar, functions of short range and long-range RADAR in ADAS, RADAR Range equation, speed detection through Radar. Lidar; Function and mechanism, Scanning, Point Cloud Processing, Use Cases. Ultrasonic Sensors; Parking Assistance and Close-Range Detection. Sensor Fusion; Combining Multiple Sensor Data.

UNIT – III (15 Lectures)

Sensor Fusion and Data Processing and Core ADAS Functions:

Kalman Filters and Sensor Fusion Algorithms, Multi-Sensor Data Processing Techniques, Localization and Mapping in ADAS.

Adaptive Cruise Control (ACC), Lane Departure Warning (LDW) and Lane Keeping Assist (LKA), Blind Spot Detection (BSD), Automatic Emergency Braking (AEB), Parking Assistance Systems, Traffic Sign Recognition (TSR).

UNIT – IV (10 Lectures)

Machine Learning & Artificial Intelligence (AI) in ADAS:

Role of AI and Deep Learning in ADAS, Convolutional Neural Networks (CNNs) for Object Detection, AI-based Decision Making in ADAS, Real-time Data Processing. Embedded Systems & Software for ADAS; Electronic Control Units (ECUs) in ADAS, Real-time Operating Systems (RTOS), Functional Safety and ISO 26262 Compliance, Middleware and Communication Protocols (CAN, LIN, Ethernet).

List of Experiments **30h**

1. Study the architecture, safety, and configuration of FMCW automotive radar development kit.
2. Configure FMCW chirp parameters and acquire raw IQ radar data using the radar SDK or capture board.
3. Perform 1-D FFT processing on acquired radar data to estimate target range and visualize the range spectrum.
4. Analyze the effect of chirp bandwidth on range resolution and measurement accuracy using experimental data.
5. Implement 2-D FFT processing to generate range–Doppler maps and detect moving targets.
6. Practice applications- automatic emergency braking (AEB), adaptive cruise control (ACC).
7. Practice applications- blind spot detection (BSD).
8. Practice applications- lane change assist (LCA).
9. Practice applications- parking assist.

Essential/recommended readings:

1. Lentin Joseph, Amit Kumar Mondal, (2021). Autonomous Driving and Advanced Driver-Assistance Systems (ADAS): Applications, development, Legal Issues, and Testing. CRC Press. (Unit-III, and Unit-IV)
2. Plato Pathrose, (2024), ADAS and Automated Driving - Systems Engineering, SAE International. (Unit-I, and Unit-II)
3. John Ball, Bo Tang, (2019), Machine Learning and Embedded Computing in Advanced Driver Assistance Systems (ADAS), MDPI. (Unit-IV)
4. Yan Li, Hualiang Shi, (2022), Advanced Driver Assistance Systems and Autonomous Vehicles: From Fundamentals to Applications, Springer. (Unit-I, Unit-II, Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 10

Biomedical Signal Processing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-10: Biomedical Signal Processing	**4**	**3**	**--**	**1**		**Instrumentation, Signals and Systems & Soft Computing**

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the concepts of biomedical signal processing and its related terminology.
2. Elaborate on the Biomedical Signal Measurement.
3. Distinguish between Single-channel and Multichannel Signal Processing and their roles.
4. How can the signal be analyzed if it is corrupted with noise?
5. Understand the role of biomedical signal processing in developing a BCI inference system.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the Human Brain and the physics of various Bio signal generation.
2. Measure the biomedical signal and its representation.
3. Describe the multichannel Signal processing tools and their role.
4. Denoising of biomedical Signals and artefact reduction.
5. Design of BCI inference system.

SYLLABUS OF DSE-10 — Total Hours: 45h

UNIT -I (12 Lectures)

Brain Structures and Scalp Potentials: Structure of the human brain, biomedical instrumentation, Physiological Signals, origin of Bio signals, Action potential, Electroencephalography, magnetoencephalography (EEG), electromyography (EMG), electrocardiography (ECG), Neural Activities, Bio signal Measurement Systems, 10-20 electrode placement system, electrodes for bio signal measurement, Measuring Electric Activity in the Brain, EEG, MEG, Event-Related Potentials (SSVEP and P300 Signals), Wearable and Wireless EEG Monitoring.

UNIT – II (10 Lectures)

Bio signal representation and artefact reduction: Classification of signals and noise, Time Series physiological
signals and their representation, rhythm of brain signals, Single/ Multi-channel EEG Time series Data, Modelling of EEG signal, Artefact identification from EEG and MEG, Digital Filters, Spatial filter: Laplacian Referencing, Common Average Referencing, Noise removal, EEG Source Localisation.

UNIT – III (10 Lectures)

Single/Multichannel Signal Processing and Pattern classification: Signal decomposition technique: Blind Source Separation, Principal Component Analysis (PCA), Independent Component Analysis (ICA), empirical mode decomposition, Filtering and Denoising, Spectral Analysis: Classical Methods, Multivariant Autoregressive (MVAR) Modelling and Coherency Maps**,** Feature Extraction (Time domain and Frequency domain), Pattern classification–supervised and unsupervised classification, Neural networks, Statistical Classifier**,** Bayes classifier.

UNIT – IV (13 Lectures)

Application of Biomedical Signal Processing: Epileptic Seizure detection, sleep disorder detection, development of user interface using bio signals for neurorehabilitation, event-related desynchronization (ERD) and event-related synchronization (ERS), Brain computer interface (BCI), BCI Paradigms, performance evaluation parameters, Different neural models and their implementation at the device level, Introduction to Neuromorphic Computing.

List of Experiments: **30h**

1. Study of biomedical signal characteristics.
2. Study signal acquisition using sensors.
3. Study Signal smoothing & denoising, Noise removal using digital filters.
4. Analysis of EMG Muscle activity.
5. Analysis of EEG band power.
6. Signal classification using machine learning.
7. Develop a real-time biomedical signal monitoring system.
8. Decomposition of single-channel and multi-channel EEG time series data and its representation in the time and frequency domains.
9. Develop a patient health monitoring system.

Essential/recommended readings:

1. W. J. Tompkins, “Biomedical Digital Signal Processing”, Prentice Hall, 1993. (Unit-I, and Unit-II)
2. Eugene N Bruce, “Biomedical Signal Processing and Signal Modelling”, John Wiley & Sons publication, 2001. (Unit-I, and Unit-III)
3. Saied Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd., 2007. (Unit-II, and Unit-IV)

Suggested Reading:

1. Leif Sornmo, Pablo Laguna: Bioelectrical Signal Processing in Cardiac and Neurological Applications, Academic Press, 2005

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11

Fiber Optics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-11: Fiber Optics	4	3	--	1	Basics of Electronics	Basics of Optics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To study the fundamentals of Optical Fibers and its Electromagnetic theory
2. To get a comprehensive understanding and hands-on exposure to the various processes, industrial tools, protocols
3. To study the different types of Fibers, sources, detectors
4. To study the link budget as applicable to the Optical Fiber Communication System

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Student will learn Familiarization of the various types of Optical Fibers and its components
2. Understanding of the Optical Fiber components, their characteristics and their applications.
3. Student will learn pre-requisite knowledge to perform design of link budget of the Optical Fiber Communication System
4. Understand the current trends, scope and future trends of the Optical Fiber Communication System.

SYLLABUS OF DSE-11 — Total Hours: 45h

UNIT -I (10 Lectures)

EM Spectrum and Optical Frequencies; Introduction to OFC, Optical Spectral bands; Basic Optical Laws and definitions, Mode Theory of Circular Dielectric Waveguides, Optical Fiber modes and configurations; Cut off wavelength and V-number of Fibers; Single mode and multi-mode fibers, Step index and graded index fibers, structure of the graded index fibers, fiber materials, Fiber fabrication, Fiber optic cables; Attenuation, Signal Dispersion in Fibers, Intermodal and Intramodal dispersion, chromatic and waveguide dispersion, group delay, polarization mode dispersion.

UNIT – II (10 Lectures)

Optical Sources, Semiconductor physics for optical sources, direct and indirect band gap semiconductors, Energy momentum diagrams; Light emitting Diodes (LEDs), Physical Structures of LEDs; Lasing actions, Different types of Lasers, Laser Diodes, Structure of Laser Diodes, Fabry Perot Cavity in Laser Diodes; Light Source Linearity. Reliability Considerations; OFC transmitter considerations, source to fiber power launching, lensing schemes for coupling improvement, fiber splicing and optical fiber connectors.

UNIT – III (10 Lectures)

Optical Detectors, Physical Principles of photodiodes, Photodetector noise, Detector response time; Avalanche and Zener breakdown, Avalanche multiplication noise; Structure of InGaAs Avalanche Photodetectors (APDs), temperature effect on Avalanche Gain, Comparison of Photodetectors; Optical receiver system, Fundamental of receiver operation, Digital Receiver performance, Eye diagrams.

UNIT – IV (15 Lectures)

Digital Links, Point to Point links, Power penalties, error control, codes for error control; Coherent detection; Analog links and its overview, Carrier to noise ratio, multi-channel transmission techniques; Microwave Photonics; Wavelength Division Multiplexing (WDM) and Dense Wavelength Division Multiplexing (DWDM); Diffraction gratings, tunable light sources. Basic applications and types of Optical Amplifiers, Semiconductor Optical Amplifiers; Erbium-Doped Fiber Amplifiers, Optical SNR, Raman Amplifiers; General Overview of non-linearities in optical fiber communication, Stimulated Raman and Brillouin Scattering; Optical Networks and Topologies, SONET/SDH; Optical Time domain reflectometry (OTDR).

List of Experiments: **30h**

1. a. Measurement of Fiber Optic Numerical Aperture
   b. Measurement of Fiber Optic using Optical Power Meter
2. a. Setting up Fiber Optical Analog Link
   b. Setting up Fiber Optical Digital Link
3. a. Study of Intensity Modulation Technique using Analog Input Signal
   b. Study of Intensity Modulation Technique using Digital Input Signal
4. a. Study of VI Characteristics of three different LED
   b. Study of Gaussian Illumination profile of three different LED
5. a. Study of Visual inspection and fault locating using OTDR
   b. Study of Variable optical attenuator (VOA)
6. a. Study of Optical fiber isolator
   b. Study of Fiber-based optical switch
7. a. Measurement of Wavelength division multiplexing (WDM) principle
   b. Study of Principle of EDFA (Erbium-doped fiber amplifier)
8. Study of Transmission of video signal through an optic fiber cable

Essential readings:

1. Keiser, G., Optical Fiber Communications, Tata Mc Graw Hills, 4th edition, 2008. (Unit-I, and Unit-II)
2. Ghatak, A., Thayarajan, K., Introduction to Fiber Optics, Cambridge University Press, 1999. (Unit-II, and Unit-III)
3. Senior, J. M., Optical Fiber Communications: Principles and Practice, Pearson education Ltd., 2009. (Unit-IV)

Suggested Readings:

1. G. Agrawal, Fiber Optic communication systems, John Wiley and Sons, 1992 (Unit-I, and Unit-II)
2. R. Singh, A. V. Agarwal, Textbook of Optical Fiber Communication, Heritage Publishers, 2019 (Unit-III, and Unit-IV)
3. S. Katiyar, A Textbook of Optical Fiber Communication Systems, S. K. Kataria & Sons, 2023 Reprint edition (Unit-IV)

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 12

Microwave Devices and Measurements

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE 12: Microwave Devices and Measurements	4	3	0	1	Entry level	Electromagnetics and Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To provide knowledge of various microwave devices to the students.
2. To have detailed knowledge of conventional as well as latest devices of RF and microwave engineering.
3. To attain the knowledge of microwave semiconductor devices & their related applications.
4. To gain knowledge of microwave sources and the integration of microwave devices with microwave-integrated circuits (MIC) and Monolithic Microwave Circuits (MMIC).

Learning Outcomes

At the end of this course, students will be able

1. To understand about the microwave devices, MIC & MMIC technologies, and related industrial requirements.
2. To have knowledge of unipolar and bipolar microwave devices including various microwave diodes and Transferred Electron devices.
3. To attain the knowledge of three terminal microwave devices and their advancement in accordance with the latest technology.
4. To gain knowledge of microwave sources and their applications and advancement.

SYLLABUS OF DSE-12 — Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to RF and Microwaves:

Guided and Unguided Medium, Frequency Spectrum, Need of High Frequency, Different Modern Applications of RF and Microwave. Active and Passive RF Components/Devices. Introduction to Microwave integrated circuits (MIC), Technology of hybrid MICs, and Monolithic Microwave Circuits (MMIC), Surface Mount Devices (SMD) & through-hole components, Integration of microwave devices with MIC and MMIC structures, Electronic packaging, Basics of RF device packaging and thermal management.

UNIT – II (15 Lectures)

Microwave Solid State Devices:

Unipolar and Bipolar Devices, Tunnel Diode, Varactor Diode, Schottky diode, Avalanche Transit Time Devices: Read, IMPATT, TRAPATT, BARITT. Transferred electron devices (TED); Gunn Diode; Gunn effect, Ridley–Watkins–Hilsum theory, Modes of operation. Microwave Transistors, Concept of Hetero-junction, Hetero-junction Bipolar Transistor (HBT), Comparison among Junction Field Effect Transistor (JFET), metal-oxide-semiconductor field-effect transistor (MOSFET), Metal-Semiconductor Field-Effect Transistor (MESFET), High

Electron Mobility Transistor (HEMT); Structure and Mechanism. Applications of Microwave Solid State Devices.

UNIT – III (10 Lectures)

Microwave Sources:

Microwave Triodes, Introduction to vacuum tubes, Linear and O-Type Tubes, Klystron; two cavity and multi-cavity, velocity modulation process, bunching process, output power and beam loading, Reflex Klystron; Power Output and efficiency, Traveling wave tubes (TWT), Slow wave structures, Magnetron; Construction & operation, Conventional tube design, Hull or single-anode magnetron, Split-anode magnetron, Cavity magnetron.

UNIT – IV (10 Lectures)

Microwave Measurements:

The Microwave Bench, detailing its modular architecture and its constituent blocks, sources, isolators, and tuners. Application of Waveguide Attenuators, Resistive Card and their types, Phase Shifter and Mode Converters. Microwave Power Measurement using the Bolometer Method, calibration of thermistors and barretters within bridge circuits. Measurement of Attenuation, Frequency (via cavity wavemeters), and Impedance, and dielectric measurement. S-parameters measurements.

List of Experiments **30h**

1. To study the VI characteristics of Tunnel Diode. And study of Tunnel Diode Amplifier and Oscillator Circuits.
2. To study the VI characteristics and capacitance of Varactor diode.
3. To study the characteristics of pin, and Schottky diodes.
4. To study the Gunn Diode and microwave Bench.
5. To study the Vector Network Analyzer (VNA) and calibration.
6. To measure the S-parameters of single-port RF device and calculation of percentage bandwidth.
7. To measure the S-parameters of dual-port RF devices and study of return loss and insertion loss.
8. To measure the dielectric constant of a material.

Essential/recommended readings:

1. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012. (Unit-II, and Unit-IV)
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012. (Unit-I, Unit-III and Unit-IV)
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003. (Unit-II, Unit-III and Unit-IV)

Reference Books:

1. George Kennedy & Bernard Davis, Electronic Communication system, 4th ed, Tata McGraw Hill Education Private Limited, 1999.
2. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 13

Modelling and Simulation of Semiconductor Devices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE- 13: Modelling and Simulation of Semiconductor Devices	4	3	--	1		Basic semiconductor physics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand Analytical modelling of MOSFETs
2. To derive and understand the mathematical equations for DC drain current in different regions of operation (cutoff, linear, and saturation).
3. To analyze the small-signal capacitances (gate capacitance, junction capacitances) and their dependence on biasing.
4. To develop the ability to model the non-classical MOS devices
5. To understand the basics of TCAD tools.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. To develop TCAD Simulation and Practical Skills
2. To create 2D/3D device structures, define doping profiles, and simulate electrical characteristics (transfer and output curves)
3. To validate analytical models by comparing them with TCAD simulation results
4. To relate device-level modeling to circuit specifications, enabling the design of efficient analog and digital circuits.

SYLLABUS OF DSE – 13 Total Hours: 45h

UNIT -I (09 Lectures)

MOS Theory & Operation:

Two-Terminal MOS Structure: band diagram, charge distribution, accumulation, depletion, inversion, weak & strong inversion, Capacitance-Voltage (C–V) characteristics. Four Terminal MOSFET: Structure and operation, channel potential, threshold voltage, drain current, gains, DC biasing and small-signal analysis, short channel Effects (SCEs)

UNIT – II (14 Lectures)

Analytical Modeling Techniques:

Poisson's equation (cartesian and cylindrical coordinates), surface potential formulation, threshold voltage formulation, drain current formulation: derivation of drain current (I_D-V_G & I_D-V_D) using the gradual channel approximation in linear and saturation regions, full range drain current modelling, impact of short channel parameters, compact analytical modeling.

UNIT – III (12 Lectures)

Advanced MOSFET Architectures:

Transition from planar to 3D architectures: Silicon on Insulator (SOI) FETs, FinFETs, Gate-All-Around FET, High Electron Mobility Transistors (HEMT), Junctionless transistor, High-k & strained-semiconductor MOSFETs, Introduction to Process Design Kit (PDK): design rules, models and applications.

UNIT – IV (10 Lectures)

Fabrication, Foundry and Numerical Simulation:

Advanced Semiconductor Fabrication Technologies, Deposition Techniques, Twin-tub CMOS fabrication, Chemical Mechanical Planarization (CMP), Foundry Overview: IDMs (Integrated Device Manufacturers), fabless, wafer fab vs. OSAT (Outsourced Assembly and Test), Cleanroom Technology: Classes of cleanrooms (ISO standards), contamination control, HEPA filters, safety protocols, and gowning procedures.

Introduction to Technology computer aided design (TCAD) tools: device simulation and process simulation. Introduction to Advanced Models: SPICE and History of SPICE modelling, types of SPICE: SPICE2, SPICE3 and HSPICE, BSIM models.

List of Experiments: **30h**

1. Plot the C-V and I-V characteristics of MOS capacitor.
2. To study the channel surface potential and electric field of MOSFET using analytical models.
3. To study and plot transfer characteristics (I_D-V_G) & output characteristics (I_D-V_D) of MOSFET.
4. Plot and analyze the impact of short channel parameters on (I_D-V_D) and (I_D-V_G) characteristics of MOSFET.
5. To study the analytical threshold voltage of MOSFET.
6. To study the impact of short channel effects, DIBL, SS of MOSFET.
7. Design and implementation of MOS devices in circuits.

Essential/recommended readings:

1. T. A. Fjeldly, T. Yetterdal, and M. Shur, “Introduction to Device Modeling and Circuit Simulation”, John Wiley, 1998. (Unit-I)
2. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 1998. (Unit-I)
3. Y. P. Tsividis, “Mixed Analog-digital VLSI Devices and Technology”, World Scientific Publishing Co Pte Ltd, 2002 (Unit-I, and Unit-II)
4. Narain Arora, “MOSFET Models for VLSI Circuit Simulation: Theory and Practice” World Scientific, 2007. (Unit-I & Unit-II, and Unit-III)
5. C K Sarkar, “Technology Computer Aided Design: Simulation for VLSI MOSFET”, CRC Press, 1st Edition, 2013, ISBN: 978-1466512658. (Unit-III, and Unit-IV)
6. J.-P. Colinge, “FinFETs and Other Multi-Gate Transistors”, Springer, 2008, ISBN: 978- 0-387- 71751-7 (Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – GE 03

Science of Microwave Heating

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE 03: Science of Microwave Heating	4	3	1	0	Entry level	Basic Knowledge of Physics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamentals of microwave technology, including electromagnetic waves, microwave theory, and wave interaction with conductors and dielectrics.
2. To learn about key microwave components like waveguides, cavity resonators, stub tuners, and directional couplers.
3. To explore microwave heating principles and dielectric and magnetic loss types and compare them with conventional heating, focusing on thermal and non-thermal effects.
4. To study the applications of microwave heating in various fields like food processing and chemistry, including specialized equipment and advanced techniques.

Learning Outcomes

At the end of this course, students will be able

1. To understand the fundamental properties of microwaves and their interaction with materials.
2. To differentiate between microwave heating and conventional thermal heating.
3. To learn to analyze the dielectric properties of materials relevant to microwave heating.
4. To gain knowledge of the principles and applications of microwave heating in various processes like extraction and digestion.
5. To evaluate different microwave processing techniques and equipment used in material processing and chemistry.

SYLLABUS OF GE-03 Total Hours: 45h

UNIT -I (11 Lectures)

Concept of Microwave:

Basics of Electromagnetic Waves, Concept of Microwave Theory, Conductor versus Dielectric materials. Waves and their polarisation, Reflection, Refraction, or Transmission. Waveguides, Modes, Cavity Resonator, Stub Tuner, and Direction Coupler Basics.

UNIT – II (12 Lectures)

Introduction of Microwave Heating:

Types of Microwave Heating, Microwave Radiation, Microwave Dielectric Heating. Basics of Dielectric Properties, Microwave versus Conventional Thermal Heating and Microwave Effects. Temperature Monitoring in Microwave Chemistry, Thermal Effects (Kinetics), Specific Microwave Effects, and Nonthermal Microwave Effects.

UNIT – III (11 Lectures)

Microwave Heating:

Fundamental principles and applications of microwave heating. Dielectric properties, permeability, and the measurement of these properties. Concept of conduction loss and dielectric and magnetic loss heating. Penetration depth and skin depth. Basics of Microwave oven, Microwave extraction and Digestion.

UNIT – IV (11 Lectures)

Material Processing and Its Equipment:

Microwave materials processing, microwave-assisted chemistry, and the potential future of microwave technology in food processing. Dedicated Microwave Reactors for Organic Synthesis. Single-Mode Instruments and Multimode Instruments. Microwave Processing Techniques - Solvent-Free Reactions, Open- versus Closed-Vessel Conditions, Pre-pressurized Reaction Vessels, Nonclassical Solvents, Passive Heating Elements.

Tutorials: 15h

1. Electromagnetic Foundations & Wave Interaction
2. Dielectric Properties & Loss Mechanisms
3. Penetration Depth and Heat Distribution
4. The "Microwave Effect" Debate
5. Instrument Architecture for Single-mode vs. Multimode
6. Safety, Industrial Scaling, and Future Trends
7. Case Studies on Microwave Industrial Heating

Essential/recommended readings:

1. Pozar DM. *Microwave Engineering*. John Wiley & Sons; 2021. (Unit-I)
2. S. Horikoshi, R. F. Schiffmann, J. Fukushima, and N. Serpone, *Microwave Chemical and Materials Processing*. Springer, 2017. (Unit-II, Unit-III, and Unit-IV)

Reference Books:

1. G. B. Awuah, H. S. Ramaswamy, and J. Tang, *Radio-Frequency Heating in Food Processing*. CRC Press, 2014. (Unit-II, and Unit-IV)
2. Kappe CO, Stadler A, Dallinger D. *Microwaves in Organic and Medicinal Chemistry*. John Wiley & Sons; 2013. (Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL BASED COURSE – SBC 03

Software Defined Radio Techniques for Modern Wireless Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-03: Software Defined Radio Techniques for Modern Wireless Systems	2	1	0	1	Entry level	Basics of analog and digital communication.

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the basic concepts and architecture of Software Defined Radio (SDR).
2. To develop familiarity with Linux-based environments and LabView/MATLAB/Python programming for SDR applications.
3. To learn to use open-source SDR software frameworks such as GNU Radio.
4. To simulate digital communication systems and visualize signal processing chains.

Learning Outcomes

At the end of this course, students will be able to

1. Describe SDR architecture and compare it with traditional radio systems.
2. Implement basic signal processing tasks using LabView/MATLAB/Python and GNU Radio.
3. Analyze and visualize signals in time and frequency domains.
4. Build and test simple digital communication links in simulation and on real SDR hardware.

SYLLABUS OF SBC-03 Total Hours: 60h

UNIT -I (20 Lectures)

Introduction to Linux environment and programming tools for signal processing, including basic Python/MATLAB/LabVIEW usage. Basics of Software Defined Radio (SDR) architecture. Fundamentals of GNU Radio and GNU Radio Companion (GRC), block-based signal flow, sources, sinks, flowgraph creation, parameter settings, and simulation workflow. Signal generation and visualization in time and frequency domains using FFT. Introduction to USRP hardware, RF signal transmission and reception, FM broadcast reception.

UNIT -2 (40 Lectures)

List of Experiments

A. Without Hardware (Simulation-based)

1. Basics of Linux environment: Basic terminal commands, installing packages, creating and running Python scripts.
2. LabView/Python/MATLAB for signal processing: Generating and plotting sine, square, and noise signals.
3. Time and frequency domain analysis FFT implementation and visualization of signals.
4. Introduction to GNU Radio Companion (GRC): Create first flowgraph using signal source, throttle, and scope sink blocks.

5. Signal modulation using GRC, Implement AM and FM modulation and demodulation.
6. Digital modulation simulation: Implement and visualize BPSK, QPSK, and QAM in GNU Radio or Python.
7. Noise and SNR analysis: Add AWGN noise to modulated signal and observe effect on BER and constellation.
8. Basic spectrum analyzer using simulated signals, Plot spectrum using FFT Sink in GNU Radio.

B. With Hardware (USRP)

1. Introduction to SDR hardware (USRP): Device setup, connection, and verification in GNU Radio.
2. FM receiver implementation: Receive live FM broadcast and play audio output.
3. Spectrum sensing / scanning: Capture live RF signals and display spectrum (FM, Wi-Fi, GSM bands etc).
4. Transmit amplitude and frequency modulated signals using SDR hardware and observe waveforms at the receiver.
5. Real-time digital modulation: Transmit and receive BPSK/QPSK/QAM signals between two SDRs. Capture received symbols and analyze constellation under various SNRs.
6. Bit error rate (BER) measurement: Implement a digital link and compute BER vs. SNR using simulated or real noise.
7. OFDM Transmission and Reception: Implement basic OFDM link using GNU Radio OFDM blocks and observe subcarrier structure.
8. Design and Implementation of an SDR-based Wireless Data (image, text or voice sample) Transmission System.

Essential/ Recommended readings:

1. Wyglinski, A. M., Getz, R., Collins, T., & Pu, D. (2018). *Software-defined radio for engineers*. Artech House. (Unit-1)
2. David Clark, Paul Clark, (2025). *Practical SDR: Getting Started with Software-Defined Radio*, No Starch Press, Inc. (Unit-2)
3. Marc Lichtman (Online) - PySDR: A Guide to SDR and DSP using Python, https://pysdr.org/ (Unit-1 and Unit-2)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 01

Research Methodology and Practices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-01: Research Methodology and Practices	2	2	-	--	Entry Level	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamental practices of Research.
2. To conceptualize various research tools.
3. To Illustrate and outline the software needed for research.

4. To understand various research practices.
5. To understand the scientific writing practices

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Understanding the basics of various research practices being followed.
2. Implement the research tools learned in their research work.
3. Determine the optimum software requirements for one's research.
4. Comprehension of various sources of errors.
5. Understand the various scientific writing practices.

SYLLABUS OF RMT-01 Total Hours: 30h

UNIT -I Various Types of Research (5 Lectures)

Introduction to Research, Types of Research: Theoretical and Experimental; Methodology with Direct and Indirect Observation and Analysis; Qualitative and Quantitative Tools; Problem identification, Literature Survey; Types of Indexing of the journals, Case Studies based on the above unit.

UNIT – II Research Methodology (10 Lectures)

Research Methodology: Top-Down approach, Inverted Pyramid, Bottom Up; Concepts of Highlighting any Text, Font size; Key Performance Indicator (KPI); Feedback System; Execution of Task: Goal Identification, Asses tools to solve, Decide Option, Implement Option; Introduction to Design thinking.

UNIT – III Design of Experiment and Error Analysis (7 Lectures)

Design of experiment, Measurement and analysis, error analysis, different types of errors, Statistical Treatment: Mean, Median, Mode, Standard Deviation, etc.; Different types of pictorial representation of data: Bar Graphs, Histograms, plots, etc.

UNIT – IV Scientific Writing and IPR (8 Lectures)

Writing scientific articles, plagiarism, research practices and ethics, referencing and styles; Intellectual Property (IP) and Intellectual Property Rights (IPR), different types of patents, Indian Patent pedagogy; presentation skills; software tools: MATLAB and its programming.

Essential readings:

1. Mishra B., Satapatty A. K., Mishra S., Consumer Electronics, Chaukhambha Orientalia, Varanasi, 2018 edition (Unit I, and Unit-II)
2. Kothari C. R., Garg G., Research Methodology: Methods and Techniques, New Age International Publishers, 2023 latest edition (Unit III, and Unit-IV)
3. Pratap R., Getting Started with MATLAB 7, Oxford University Press, 2006 edition. (Unit IV)

Suggested Readings:

1. Aguinis H., Research Methodology: Best Practices for Rigorous, Credible, and Impactful Research, Sage, 2024, latest edition (Unit I, and Unit-II)
2. Jain R. K., Research Methodology: Methods and Techniques, Vayu Education of India, 2021, latest edition (Unit III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 02

Tools for Research

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-02: Tools for Research	2	2	-	--	Entry Level	Software programming, Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand computational, simulation, and experimental tools used in electronics research.
2. Apply numerical computing and data analysis for modeling and measurements.
3. Use laboratory instrumentation and characterization techniques effectively.
4. Develop skills in scientific analysis, documentation, and research reporting.

Learning Outcomes

After completing the course, students will be able to:

1. The Learning Outcomes of this course are as follows:
2. Apply computational and simulation tools to analyze research problems.
3. Perform experimental measurements and interpret characterization data.
4. Validate results using statistical and error analysis methods.
5. Prepare professional scientific documents with proper visualization and references.

SYLLABUS OF RMT-02 — Total Hours: 30h

Unit I: (7 Lectures)

Computational Tools:

Role and significance of computational tools in electronics research; numerical computing environments including MATLAB, GNU Octave, and Python (NumPy, SciPy); matrix operations, numerical methods, and scientific scripting for modeling and data analysis; use of Jupyter Notebook for research and documentation.

Unit II: (7 Lectures)

Computer Simulation and Design Tools:

Classification and application of simulation and design software across electronics domains; comparison of open-source and commercial research tools with licensing and cost considerations; criteria for selection, validation, benchmarking, and verification of simulation results; introductory concepts of Multiphysics simulation and co-simulation in advanced electronics research.

Unit III: (8 Lectures)

Experimental and Measurement Tools:

Laboratory instrumentation used in electronics research; data acquisition methods, sensor interfacing,

calibration procedures; overview of basic microfabrication and PCB prototyping technologies; fundamentals of automated measurements using software-controlled instrumentation. Tools for Electrical, Structural and Optical Characterization: C-V, I-V, X-Ray Diffraction, SEM, TEM, AFM, UV-visible-NIR Spectroscopy, PL, Raman Spectroscopy.

Unit IV: (8 Lectures)

Data Analysis and Technical Documentation:

Scientific data processing, visualization, and statistical interpretation; error analysis, uncertainty estimation, and validation of experimental results; reference and citation management using Mendeley, Zotero, and EndNote;-preparation of technical documents using LaTeX for research papers, theses, and reports; creation of scientific diagrams and plots using Origin, Visio, and Python libraries.

Essential/recommended readings:

1. Heath, M. T. (2018). Scientific computing: An introductory survey (2nd ed.). McGraw-Hill. (Unit I, and Unit IV)
2. Chapra, S. C., & Canale, R. P. (2020). Numerical methods for engineers (8th ed.). McGraw-Hill Education. (Unit I, and Unit II)
3. Horowitz, P., & Hill, W. (2015). The art of electronics (3rd ed.). Cambridge University Press. (Unit III)
4. Taylor, J. R. (1997). An introduction to error analysis: The study of uncertainties in physical measurements (2nd ed.). University Science Books. (Unit III, and Unit IV)

Suggested Books:

1. Chapra, S. C. (2024). Applied Numerical Methods with Python for Engineers and Scientists. McGraw-Hill Education. (Unit I, and Unit II)
2. McKinney, W. (2022). Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter (3rd ed.). O'Reilly Media.(Unit I, and Unit IV)
3. Verma, M. (2021). Practical Numerical Computing Using Python: Scientific & Engineering Applications. (Self-published/academic).(Unit I, and Unit IV)
4. Dinov, I. D. (2023). Data Science and Predictive Analytics: Biomedical and Health Applications using R (2nd ed.). Springer. (Unit IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 10

Advanced Digital Signal Processing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-10: Advanced Digital Signal Processing	4	3	--	1		Signals and Systems, Digital Signal Processing

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the concepts of Advanced signal processing and its related terminology.
2. Elaborate on the time frequency analysis.
3. Distinguish between Parametric and Non-parametric Power Spectrum estimation
4. Implement the Weiner and Kalman filter for a real-time application.
5. Understand the programming model of the Digital Signal Processor.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the concept of Time frequency analysis and its scope.
2. Describe the Multi-rate Digital Signal Processing.
3. Implement Optimum linear filters for noise cancellation.
4. Represent the Spectrum of real-time series data using Parametric and non-parametric methods of Spectrum Estimation.
5. Understand the programming model of the DSP processor and its real-time implementation.

SYLLABUS OF DSC-10 — Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to Digital Signal Processor, Architecture of DSP Processor, Programming Model, Time-Frequency Analysis: Introduction to time frequency analysis, Windowed Fourier transforms (STFT), Signal representation with continuous and discrete STFT, Wavelet Transform, Stockwell transform, Wigner-Ville transform, Cohen's Class distribution. Chirp Z Algorithm, Goertzel's Algorithm**.**

UNIT – II (10 Lectures)

Discrete sine and cosine transform, Discrete Hartley transform, Multi-rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, polyphase filters, QMF, digital filter banks, Multi-resolution signal analysis, wavelet decomposition, DWT, Wavelet Packet,
Applications in sub-band coding.

UNIT – III (10 Lectures)

Linear prediction and Optimum Linear Filters: Random signals and power spectra, Forward and backward Linear

prediction, solutions of the normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters and Kalman Filter. Adaptive filter.

UNIT – IV (13 Lectures)

Power spectrum estimation: Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenvalue decomposition-based Spectrum Estimation.

List of Experiments **30h**

1. Write a program to implement time frequency analysis in MATLAB.
2. Write a program to implement power spectrum estimation methods in MATLAB.
3. Write MATLAB code to implement the Weiner and Kalman filter to denoise the noisy signal.
4. Develop an adaptive filter algorithm for sinusoidal Noise Cancellation using TMS320C6748 - Fixed/ Floating Point Digital Signal Processor. [Code Composer Studio (CCS)]
5. Generation of the Frequency Response of the DAC Reconstruction Filter using a Pseudorandom Binary Sequence with the help of the TMS320C6748 processor. [CCS]
6. Develop a fourth-order Elliptic low-pass IIR Filter Designed Using FDA tool.
7. Develop the code for the implementation of four different filters: Low pass, High Pass, Band Pass and Band Stop using the TMS320C6748 processor. [CCS]
8. Implementation of an IIR filter using a cascade second-order filter. [CCS]
9. DFT of a Sequence of Real Numbers with Outputs in the CCS graphical display window. [CCS]

Essential/recommended readings:

1. J.G.Proakis and D.G.Manolakis “Digital signal processing: Principles, Algorithm and Applications”, 5th Edition, Pearson, 2021. (Unit I, and Unit III)
2. N. J. Fliege, “Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets”, 1st Edition, John Wiley and Sons Ltd, 1999. (Unit-I, and Unit-II)
3. D. G. Manolokis, V. K. Ingle and S. M. Kogar, “Statistical and Adaptive Signal Processing”, Mc Graw Hill International Edition, 2000. (Unit-III)
4. S. Haykin and T. Kailath, Adaptive Filter Theory, Pearson Education, 4th Edition, 2005. (Unit-III, and Unit-IV)

Suggested Reading:

1. Discrete Wavelet Transform: A Signal Processing Approach, by D. Sundararajan, John Wiley and Sons Inc., 2015 (Unit-I)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 11

Principles of VLSI Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-11: Principles of VLSI Design	4	3	--	1		Basics of analog and digital electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To introduce the VLSI design hierarchy, abstraction levels, and overall design flow.
2. To develop understanding of CMOS logic circuits and common combinational and sequential building blocks.
3. To enable analysis of timing, power, and performance trade-offs in VLSI systems.
4. To familiarize students with physical design concepts and verification methodologies.
5. To build a foundation for advanced study or industry applications in VLSI design.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Explain the VLSI design hierarchy, abstraction levels, and end-to-end design flow.
2. Design and analyze basic CMOS combinational and sequential circuits using appropriate logic styles.
3. Evaluate timing and power characteristics of VLSI circuits and identify critical design trade-offs.
4. Apply physical design concepts such as floor planning, placement, routing, and verification at a conceptual level.
5. Relate VLSI design methodologies to practical implementation and further studies in integrated circuit design.

SYLLABUS OF DSC -11 Total Hours: 45h

UNIT -I (10 Lectures)

VLSI Design Flow and Abstraction:

VLSI system hierarchy, design complexity, and need for abstraction at system, architectural, logic, circuit, and layout levels. Top-down and bottom-up design approaches and representations at each abstraction level. Overview of ASIC design flow from specification to fabrication, including design entry using HDL and verification. Standard-cell based design methodology, IP blocks, and comparison of ASIC and FPGA design flows.

UNIT – II (12 Lectures)

CMOS Logic Circuits and Building Blocks:

CMOS implementation of basic combinational logic gates and arithmetic circuits. Multiplexers, encoders, decoders, and XOR/XNOR circuits. Pass transistor logic and transmission gate logic: operation, advantages, and limitations with logic realization. Sequential elements (latches and flip-flops) and design considerations in terms of speed, power, and area.

UNIT – III (11 Lectures)

Timing and Power Considerations in VLSI:

Propagation delay, rise/fall times, critical path, and timing constraints in synchronous systems. RC delay models, interconnect delay, setup/hold time, and clock skew effects. Dynamic and leakage power dissipation in CMOS circuits and influencing factors. Power–delay trade-off and low-power design considerations.

UNIT – IV (12 Lectures)

Physical Design Concepts:

Physical design flow and its role in VLSI implementation. Floor planning, area estimation, placement, and routing concepts. Impact of interconnect and parasitic effects on timing and performance. Physical verification techniques including DRC, LVS, and parasitic extraction.

List of Experiments: **30h**

1. Study of VLSI Design Flow and Abstraction Levels.
2. Design and Simulation of CMOS Inverter
3. Design of Basic CMOS Logic Gates (NAND, NOR, XOR)
4. Design of Combinational Circuits (Multiplexers, Encoders, Decoders)
5. Design and Analysis of Pass Transistor and Transmission Gate Logic Circuits
6. Design of Sequential Circuits (Latches and Flip-Flops)
7. Timing Analysis of Digital Circuits
8. Power Analysis of CMOS Circuits.

Essential/recommended readings:

1. Rabaey, J. M., Chandrakasan, A., Nikolić, B Digital Integrated Circuits: A Design Perspective, 3rd Edition, Pearson Education, 2019. (Units-I, Unit-II and Unit-III)
2. Weste, N. H. E., Harris, D. CMOS VLSI Design: A Circuits and Systems Perspective, 4th Edition, Pearson Education, 2011. (Units-I, Unit-II, Unit-III, and Unit-IV)
3. Kang, S. M., Leblebici, Y. CMOS Digital Integrated Circuits: Analysis and Design, 4th Edition, McGraw-Hill Education, 2015. (Units II, Unit-III and Unit-IV)

Suggested / Supplementary Readings

1. Wolf, W. Modern VLSI Design: Systems on Silicon, 4th Edition, Pearson Education, 2008. (Units I, and Unit-IV)
2. Uyemura, J. P. Introduction to VLSI Circuits and Systems, Wiley, 2002. (Units I, and Unit-II)
3. Pedram, M., Rabaey, J. (Eds.) Power Aware Design Methodologies, Springer, 2002. (Unit-III)
4. Baker, R. J. CMOS: Circuit Design, Layout, and Simulation, 3rd Edition, Wiley-IEEE Press, 2019. (Units II, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 14

Artificial Intelligence & Robotics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-14: Artificial Intelligence & Robotics	4	3	--	1		Biology, Mathematics & Embedded Systems

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the importance, applicability and strength of AI.
2. Elaborate search and knowledge representation schemes for intelligent systems
3. Understand the logics and knowledge representation techniques.
4. Understand the basics of logical programming PROLOG.
5. Explain the design of the robot.

Learning Outcomes

At the end of this course, students will be able to

1. Implement the AI techniques in the field of Electronics.
2. Apply various search and knowledge representation schemes for intelligent systems.
3. Explain the logic and knowledge representation techniques.
4. Demonstrate the various phases involved in the development of the Expert system.
5. Design and development of a robot.

SYLLABUS OF DSE-14 — Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to AI:

Definition and history of AI, Domains and Applications of AI, advantages and disadvantages of AI, Subsets of AI, Intelligent agents in AI and their types, Agent Environment in AI, Turing Test.

UNIT – II (10 Lectures)

Searching techniques:

Search Algorithm Terminologies, Properties of search algorithms, types of search algorithms, Breadth-first search, Uniform cost search, Depth-first search, Best-first search, A* search, Hill climbing algorithm.

UNIT – III (10 Lectures)

Knowledge Representation:

Knowledge-Based Agent and its architecture**,** types of knowledge, Techniques of knowledge representation, Propositional logic, Syntax & semantics for Propositional logic, rules of inference, First-order logic (FOL) and

syntax, Inference rules for FOL. Introduction to logical programming, PROLOG. Machine learning.

UNIT – IV (13 Lectures)

Introduction to Robotics:

Basic: Robot-Basic concepts, Need, Robot configurations-cartesian, cylinder, polar and articulate. Robot wrist mechanism, Precision and accuracy of the robot, and safety standards.

Sensors and Actuators in robotics: Touch sensors, Tactile sensors, proximity and range sensors, Pressure sensors, Actuators: DC Motor, Servo Motor and Stepper Motor.

Applications: Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defence, and Disaster management.

List of Experiments **30h**

1. Understanding of the programming model of STM32CubeIDE, NanoEdge AI Studio, and development tools. Programming for TinyML and Edge AI.
2. Multi-sensor data fusion and on-device AI decision making.
3. Write a PRO LOG program for Family Relationships.
4. Human activity recognition using motion sensors.
5. Motion and Vibration Sensor Interfacing.
6. To display real-time sensor data on OLED.
7. Forward kinematics and validate using any software (Robo analyzer or other).
8. Demonstration of a robot with 2 DOF, 3 DOF, 4 DOF using any software (Robo analyzer or other).
9. Design a Robotic Arm using Arduino.

Essential/recommended readings:

1. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 4e , 2022. (Units-I, and Unit-II)
2. Vinod Chandra S.S., and Anand Hareendran S. Artificial Intelligence and Machine Learning 1st Edition., PHI, 2014. (Units-I, and Unit-II)
3. Dan W. Patterson, Introduction to artificial intelligence and expert systems, 1st edn, Pearson, 2015. (Units-I, and Unit-III)
4. John Craig, Introduction to Robotics, Pearson, 2022. (Unit-IV)
5. S.K Saha, Introduction to Robotics, Magraw Hill, 2024. (Unit-IV)

Suggested reading:

1. Saroj Kaushik: Artificial Intelligence, Cengage, 2nd Edition, 2022.
2. Peter J. Bentley : Artificial Intelligence and Robotics: Ten Short Lessons (Pocket Einstein Series), Johns Hopkins University Press,2020.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 15

Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-15: EMI & EMC	4	3	-	1	Entry level	Basics of Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the significance of EMI/EMC in the design of electrical and electronic products.
2. To learn about EMI sources, coupling mechanisms, and their impact on system performance.
3. To gain knowledge of international EMI/EMC standards and test procedures.
4. To explore various EMI control techniques such as grounding, shielding, and filtering.
5. To develop good design practices for achieving EMC compliance at circuit and PCB levels.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the concepts and importance of EMI and EMC in product design.
2. Identify EMI sources and apply suitable control and mitigation techniques.
3. Interpret and follow relevant EMI/EMC standards and testing methods.
4. Design circuits and PCBs with improved EMC performance.
5. Apply good design practices to ensure reliable and compliant electronic systems

SYLLABUS OF DSE-15 — Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to EMI / EMC, EMI scenarios, EMI sources, coupling mechanism & modes- common and differential modes, EMI victims, classification of disturbance phenomena, Time & frequency domain analysis, Emission and Susceptibility.

UNIT – II (11 Lectures)

EMI/EMC Standards & Measurements, Standard making bodies, commercial & MIL Standards (FCC, CISPR etc.), Emission and Immunity tests, Test instrumentation, compliance & diagnostic testing.

UNIT – III (11 Lectures)

EMI Control Techniques, Grounding & Cabling, Filtering & Shielding, Transient suppression & ESD Control.

UNIT – IV (11 Lectures)

Design for EMC (Emission & Susceptibility control at PCB level), Components & Circuit selection, Circuit layout, Partitioning, Chassis bonding, Grounding, PCB stack-up, Transmission line termination, Decoupling, PSU design.

List of Experiments: **30h**

1. To study the noise coupling between twisted and untwisted wires using an oscilloscope.
2. To study the conducted EMI from a DC power supply or motor circuit.
3. To study the radiated EMI from a digital circuit or switching power supply.
4. To measure the electromagnetic radiation emitted by a device using spectrum analyzer
5. To study the effect of metallic and non-metallic enclosures on EMI.
6. To evaluate the effectiveness of various shielding materials in preventing electromagnetic interference.
7. To study the crosstalk between parallel PCB traces or cables by measuring the induced noise at varying separation distances.
8. To study the EMI/EMC test using a GTEM cell.

Essential/recommended readings:

1. Kumar, L. A., & Maheswari, Y. U. (2024). Electromagnetic interference and electromagnetic compatibility: Principles, design, simulation, and applications. 1st Edition, CRC Press. (Unit I, II, III and IV).
2. Mardiguian, M. (2025). Electromagnetic compatibility: Understanding, design, and testing with practical solutions. 1st Edition, Springer. (Unit I, II, and III).
3. Ott, H. W. (2011). Electromagnetic Compatibility Engineering. John Wiley & Sons. (Unit I, II, III and IV).

Suggested Books:

1. Archambeault, B., & Drewniak, J. (2013). PCB design for real-world EMI control. Springer. (Unit I, III, and IV)
2. Nguyen, K. (2025). Grounding, shielding & EMC for builders: Quiet circuits: Practical grounding, shielding & EMC for projects,1st ed. Independently Published. (Unit III and IV)
3. Paul, C. R., Scully, R. C., & Steffka, M. A. (2022). Introduction To Electromagnetic Compatibility. John Wiley & Sons. (Unit I- IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 16

Fundamentals of MEMS Technologies

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course
		Lecture	Tutorials	Practical/ Practice		
DSE-16 Fundamentals of MEMS Technologies	4	3		1	Entry Level	Electromagnetics

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspects of MEMS technologies.
2. Basic knowledge of Essential Materials for MEMS fabrication.
3. The course educates the students on the understanding mechanism behind Actuators and Sensors.
4. The course educates the students on the working principles of MEMS-based RF and Optical Technologies.

Learning Outcomes

At the end of this course, students will be able

1. To understand basic principle of MEMS operation.
2. To design the various MEMS structures
3. To acquire a knowledge on Actuators and Sensors and operational principle.
4. To design requirements for RF MEMS components

SYLLABUS OF DSE-16 — Total Hours: 45h

UNIT -I (11 Lectures)

Introduction:

History of MEMS Development, Intrinsic characteristics of MEMS, Electrical and Mechanical Properties of Materials for MEMS, Electrical and Mechanical Properties, Miniaturization, Scaling issues, Micromachining: bulk, surface and dry micromachining, Microelectronics Integration, Transduction Principles: Electrostatic and Capacitive, Electromagnetic, Piezoelectric and Thermal Transductions. Mass fabrication with precision. Micro fabrication - microelectronics fabrication process- silicon based MEMS processes and fabrication processing.

UNIT -II (12 Lectures)

Sensors and Transducers:

Principles, Classifications, Characteristics; Recent Trends in Sensor Technologies, Electromechanical transducers: Piezoelectric transducers, Electrostatic sensing and actuation-parallel plate capacitor, Tactile sensor parallel Plate actuator- comb drive. Thermal sensing and actuations-thermal sensors-actuators. Smart Sensors, Sensors and their Applications.

UNIT -III (12 Lectures)

RF Technologies:

Need for RF MEMS components in communications, space and defense applications, Materials and fabrication technologies, Actuation methods in MEMS, Special considerations in RF MEMS design. RF MEMS components: Micro-switches, Planar, on-chip components, Transmission lines and other components, Micromachined antennas, Micromachined phase shifters.

UNIT -IV (10 Lectures)

Optical Technologies:

Optical MEMS and Optofluids, Optical materials for MEMS, Challenges in optical MEMS fabrication, MEMS scanning micromirror, MEMS based endoscopy, Microlens, Microcamera.

List of Experiments: — 30h

1. Design and Simulation of Cantilever Beam Sensor.
2. Design and Simulation of Pressure Sensor.
3. Design and Simulation of a Fluid-Filled RF-based MEMS Switch.
4. Design and Simulation of MEMS-based Surface Acoustic Wave Gas Sensor.
5. Design and Simulation of an RF-based MEMS planar component.
6. Design and Simulation of an Optical-based MEMS component.

Essential/recommended readings

1. Eun Sok. Kim, Fundamentals of Microelectromechanical Systems (MEMS). 1st ed. New York: McGraw Hill, 2021 for Unit-I, III and IV D. Patranabis, Sensors and Transducers, 2nd Edition. (UNIT-II)
2. V. K.Varadan, K. J. Vinoy, and K.J. Jose, RF MEMS and their Applications, John Wiley & Sons. 2002. (Unit – III, and Unit-IV)

3. H. J. De Los Santos, RF MEMS Circuit Design for Wireless Communications, Artech House. 1999. (Unit – III)
4. Hongrui Jiang, Optical MEMS for Chemical Analysis and Biomedicine, Institution of Engineering and Technology, London, United Kingdom, first edition, 2016. (Unit – IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 17

Modern Communication Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-17: Modern Communication Systems	4	3	0	1	Entry level	Analog and Digital Communication.

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course enables students to attain successful professional careers by applying their engineering skills in communication system design to meet out the challenges in industries and academia.
2. The course develops a strong foundation in the field of Satellite Communication, earth and space subsystems involved and their importance; multiple access techniques.
3. To understand the fundamental and recent technological developments in Mobile communication systems.
4. To understand the knowledge Internet of Things is, RFID Technology, Sensor Technology and Satellite Technology.

Learning Outcomes

At the end of this course, students will be able

1. To provide students with strong fundamental concepts and also advanced techniques and tools to build various communication systems.
2. To enable students to attain successful professional careers by applying their engineering skills in communication system design to meet out the challenges in industries and academia.
3. To engage students in lifelong learning, adapt emerging technology and pursue research for the development of innovative products.

SYLLABUS OF DSE-17 — Total Hours: 45h

UNIT -I (10 Lectures)

Satellite Communication:

Radiation and propagation of waves: fundamental of EM waves and their effects ground, sky and space waves propagation, Orbits and Launching Methods, Space Link Budget, Space and Earth Segment, Satellite Services.

UNIT – II (10 Lectures)

Wireless Communication:

Fundamental concepts in wireless, Basic Terminologies, cellular technology, GSM, GPRS, 3G, 4G, 5G, Standards evolved, Mobile Radio Propagation, Mobile System and Network Architectures, Advanced Wireless IP network Architectures, Wireless Standards.

UNIT – III (15 Lectures)

Data transfer and Computer Networking:

Packet switching, ISDN, ATM, LAN, WAN, Internet and WAP, Digital Radio Communication Systems; Multiple Access Techniques: Frequency Hopping Spread Spectrum (FHSS) systems, Direct Sequence Spread Spectrum, Code Division Multiple Access of DSSS.

UNIT – IV (10 Lectures)

Internet of Things:

Introduction, Fundamental IoT Mechanisms and Key Technologies, Radio Frequency Identification Technology, Resource management in IoT, IoT Privacy, Security and Governance, Business models for IoT.

List of Experiments **30h**

1. To Establish a voice/video link between an uplink transmitter and a downlink receiver.
2. To Study Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS) techniques.
3. To calculate carrier-to-noise ratio (SNR) for uplink and downlink.
4. To study Minimum Shift Keying (MSK) modulation and demodulation.
5. Use software (MATLAB) to determine satellite position, velocity, and visibility, including Keplerian elements.
6. To determine longitude, latitude, and altitude using a GPS receiver.
7. Functional study and block diagram study of mobile communication through mobile trainer kit.
8. Signal analysis and measurement of mobile communication.
9. Study of automation through I.O.T.

Essential/recommended readings:

1. Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J. (2017). IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press. (Unit-IV)
2. Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson. (Unit-II)
3. T. Pratt, C. Bostain & J. Allnutt. (2003). Satellite Communication, Wiley. (Unit-I)

Reference Books:

1. Rappaport, T. S. (2024). Wireless communications: principles and practice. Cambridge University Press. (Unit-II)
2. Forouzan, B. A. (2007). Data communications and networking. Huga Media. (Unit-III)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE 18
Modern Antennas

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-18: Modern Antennas	4	3	--	1		Basics of Electromagnetics and transmission lines

Learning Objectives

1. To understand the fundamentals of antenna theory and electromagnetic radiation principles.
2. To analyze key antenna parameters such as gain, polarization, beamwidth, directivity, and efficiency.
3. To derive and evaluate the radiation fields of various antennas, including wire, aperture, and microstrip antennas, along with appropriate feeding techniques and circular polarization concepts.
4. To apply the principles of antenna arrays, including beam steering, null steering, and adaptive/smart antenna techniques.
5. To design and analyze modern antenna systems such as reconfigurable, fractal, metamaterial/metasurface, holographic, wearable, biomedical, IoT, and millimeter-wave antennas for practical applications.

Learning Outcomes

At the end of this course, students will be able to:

1. Explain the radiation mechanism of antennas and evaluate key antenna parameters such as gain, directivity, polarization, beamwidth, and efficiency.
2. Derive and analyze the field components of wire antennas including dipole, loop, helix, and Yagi–Uda antennas.
3. Compute and evaluate the field components and radiation characteristics of various aperture antennas.
4. Analyze and design linear and planar antenna arrays, and implement beam scanning techniques using Binomial and Chebyshev distributions.
5. Design and assess modern antenna systems such as reconfigurable, fractal, metamaterial/metasurface, holographic, wearable, biomedical, and IoT antennas for contemporary applications.

SYLLABUS OF DSE-18 — Total Hours: 45h

UNIT -I (10 Lectures)

Antenna fundamentals and parameters:

Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Maximum Directivity and Maximum Effective Area, and Antenna Polarization, Antenna Apertures, and near-field and far-field concepts. Types of Antennas, Radiation Mechanism and Current Distribution on a Thin Wire Antenna. Radiation integrals and vector potential.

UNIT -II (11 Lectures)

Conventional Antennas:

Dipole, monopole, loop and helical antennas, Yagi-Uda, and horn antennas, Reflector antennas: parabolic reflectors, Cassegrain feed, Microstrip patch antenna: types, analysis, feeding techniques, Design parameters: bandwidth, substrate effects, impedance matching, Circularly polarized and broadband patch designs.

UNIT -III (12 Lectures)

Antenna Arrays and Beamforming:

Two Element Array, N-Element Linear Array- Uniform amplitude and Spacing, Broadside Array, Ordinary End-Fire Array, Phased Array, Array factor and pattern multiplication, Beam steering and null steering techniques, Adaptive and smart antenna concepts, Introduction to MIMO and beamforming for 5G.

UNIT -IV (12 Lectures)

Modern and Emerging Antennas:

Reconfigurable antennas (frequency, pattern, and polarization reconfigurability), Fractal antennas and miniaturization techniques, Metamaterial and metasurface antennas, Holographic Antenna, Wearable, biomedical, and implantable antennas, Antennas for IoT.

List of Experiments: **30h**

1. To study and design of Dipole antenna and analysis of its various parameters.
2. Study the Effect of a Perfect Electric Conductor (PEC) and a Perfect Magnetic Conductor on dipole antenna performance.
3. To study and design of microstrip Rectangular and Square patch antenna
4. To study and design of microstrip Circular Patch Antenna
5. To study the effect of various feeds in the microstrip Patch antenna.
6. To study and design of circularly polarized microstrip antenna.
7. To study and design of planar microstrip array antenna (1×2)
8. To study and design of MIMO antenna and analyse its various parameters.
9. To study and design of Aperture antenna (rectangular slot)
10. Measurement of a radiation pattern of dipole and Yafi-Uda antenna. Analysis of co-polarization and cross-polarization.

Essential/recommended readings:

1. C. A. Balanis, Antenna Theory: Analysis and Design, Wiley. (Unit-I, Unit-II, Unit-III, and Unit-IV)
2. W. L. Stutzman and G. A. Thiele, Antenna Theory and Design. (Unit-I, and Unit-II)
3. R. S. Elliott, Antenna Theory and Design, Wiley. (Unit-II)
4. K. F. Lee and K. M. Luk, Microstrip Patch Antennas. (Unit-II)
5. Y. Lo and S. Lee, Antenna Handbook. (Unit-III)
6. Constantine A. Balanis, Modern Antenna Handbook, Wiley. (Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – GE-04

Consumer Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-04: Consumer Electronics	4	3	1	--	Entry Level	Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To discuss the concepts of audio and video system fundamentals.
2. To conceptualize the analogous system and their work mechanism.
3. To illustrate and outline the Television system.
4. To understand various electronic devices of popular use.
5. To explain the component level understanding of the devices.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Student will Understand the component and system level understanding of the electronic devices.
2. Student will learn to describe the interconnections of components to achieve the system in device electronics.
3. Student will determine the response of system.
4. Synthesize the electronic device with the help of Electrical Elements.
5. Student will learn the description of modern TV systems and other devices

SYLLABUS OF GE-04 — Total Hours: 45h

UNIT -I (12 Lectures)

Audio Fundamentals and Devices:

Basic characteristics of sound signal: level and loudness, pitch, frequency response, fidelity and linearity, Reverberation; Audio level metering, decibel level in acoustic measurement; Microphone: working principle, sensitivity, nature of response, directional characteristics; Types: carbon, condenser, crystal, electrets, tie- clip, wireless; Loud speaker: working principle, characteristic impedance, watt

Capacity; Types: electrostatic, dynamic, permanent magnet etc , woofers, and tweeters; Sound recording: Optical recording, stereophony and multichannel sound, MP3 standard.

UNIT – II (10 Lectures)

Audio Systems:

Audio system: CD player, home theatre sound system, surround sound; Digital console: block diagram, working principle, applications; FM tuner: concepts of digital tuning, ICs used in FM tuner TDA 7021T; PA address system: planning, speaker impedance matching, Characteristics, power amplifier, Specification.

UNIT – III (13 Lectures)

Television Systems:

Picture resolution; Composite video signal: horizontal and vertical sync details, scanning sequence; Colour TV standards, colour theory, hue, brightness, saturation, luminance and chrominance; Different types of TV camera; Television Receivers and Video Systems: block diagram, Precision IN Line colour picture tube; Digital TVs:- LCD, LED ,PLASMA, HDTV, 3-D TV, projection TV, DTH receiver; Video interface: Composite, Component, Separate Video, Digital Video, SDI, HDMI Multimedia Interface) , Digital Video Interface; USB stick: working principles, interfaces.

UNIT – IV (10 Lectures)

Home/Office Appliances:

Scanner; Microwave Oven: types, single chip controllers, wiring and safety instructions, technical specifications; Washing Machine: wiring diagram, electronic controller for washing machine, technical specifications, types of washing machine, fuzzy logic; Air conditioner and Refrigerators: Components features, applications, and technical specification; Digital camera and cam coder: pick up devices, picture processing, picture storage**.**

Tutorials: 15h

List of Activities under Tutorials:

1. Case Study on Audio system specifications and applications, fidelity factor, etc.
2. Comparison between various loudspeakers and microphones
3. Understanding the features of various types of Smart TVs and smart gadgets
4. Seminar on emerging consumer electronics gadgets to be integrated with 5G, 6G technologies
5. Case studies on IoT based Smart Home systems

Essential/Recommended Readings:

1. Gupta B. R., Singhal V., Consumer Electronics, S. K. Kataria & Sons India, 2023 edition (Unit I, and Unit-II)
2. Hetrelezis P., Consumer Electronics: Repair, Reuse and Recylcing, Elektor Publishing, 2024 latest edition (Unit III, and Unit-IV)
3. Gulati R.R., Modern Television practices, New Age International Publication (P) Ltd. New Delhi Year 2023, latest edition. (Unit III)

Suggested Readings:

1. Whitaker Jerry & Benson Blair, Mastering Digital Television, McGraw-Hill Professional, 2023, latest edition
2. Whitaker Jerry & Benson Blair, Standard handbook of Audio engineering, McGraw-Hill Professional, 2023, latest edition
3. Latest User Manuals from Philips, Dell and HP for the new generation devices.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL BASED COURSE – SBC-04

Electronic Materials and Devices Fabrication

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course
		Lecture	Tutorials	Practical/ Practice		
SBC – 04 Electronic Materials and Devices Fabrication	**2**	**1**	**0**	**1**		**Basic Electronic Materials**

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspect of semiconductor process technologies.
2. This course will create the foundation of Fabrication Techniques for Semiconductor Materials and Devices.
3. The course educates the students with the understanding science behind fabrication techniques of micro/nano electronic devices.
4. The main objective is to train the manpower/students in the field of semiconductor science and technology relevant to modern electronic industry/technology.

Learning Outcomes

At the end of this course, students will be able

1. To understanding role of Semiconductor Devices in duality human life.
2. To able to use vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
3. To skilled over Device Isolation, Contacts and Metallization for CMOS Applications.
4. To trained manpower will be conversant with various processes and instruments to fabricate the electronic materials and devices.

SYLLABUS OF SBC-04 — Total Hours: 60h

Unit 1:

Over view of semiconductor wafer and electronic devices processing, clean room specifications and importance; Isolation: mesa isolation, Oxide isolation; Self-Alignment; Local oxidation: Trech Technique; Planarization: Chemical and mechanical Polishing; Metallization; Planar and Mesa structures; Device packing basics: System on chip (SOC) and System on packing (SOP) wire bonding techniques for IC fabrication.

Unit 2: List of Experiments

1. Demonstrate Semiconductor thin films fabrication by Physical/chemical vapor deposition techniques.
2. Doping (n- or p-type) of intrinsic semiconductors.
3. Polymer thin film depositions: Spin coating techniques.
4. Semiconductor thin film characterization and analysis: crystalline quality, optical defects, bandgap identification etc.
5. Thin film deposition on flexible substrates using screen-printing technique for flexible electronic device applications.
6. Device characterization and analysis: Semiconductor parameter analyzer.

Essential/recommended readings

1. Sorab K. Ghandhi, VLSI Fabrication Principles, 2nd Edition, Wiley
2. Fundamentals of Device and Systems Packaging: Technologies and Applications by Rao R. Tummala, McGraw-Hill Publications

Reference Books:

1. G. S. May and S. M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley India, 2004
2. Stephen A. Campbell, Fabrication engineering at the micro-and nanoscale, 4th Edition, Oxford University Press, 2008
3. M. J. Madou, *Fundamentals of Microfabrication*, 2nd Edition, CRC Press, 2011.

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RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 03

Techniques of Research Writing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-03: Techniques of Research Writing	2	2	0	0	Entry level	N.A.

Learning Objectives

Students will learn to:

1. Produce structured academic papers (paragraphs, essays, reports).
2. Use academic language effectively and appropriately.
3. Properly document sources to maintain academic integrity.
4. Critically read and analyze academic texts.

Learning Outcomes

At the end of this course, students will be able to

1. Write a technical paper.
2. Understand academic language.
3. Have knowledge of references, and citation.
4. Develop the knowledge of machine learning and artificial intelligence in ADAS.

SYLLABUS OF RMT-03 Total Hours: 30h

UNIT -I (7 Lectures)

Introduction to Academic Writing:

Purpose, audience, tone, and features (objectivity, precision, formality).

The Writing Process:

Brainstorming, outlining, drafting, revising, and proofreading.

UNIT – II (8 Lectures)

Paragraph & Sentence Structure:

Topic sentences, coherence, cohesion, and paragraph development (descriptive, opinion, comparison).

Essay Types:

Expository, argumentative, and compare/contrast essays.

UNIT – III (8 Lectures)

Working with Sources:

Paraphrasing, summarizing, quoting, and avoiding plagiarism.

Referencing & Citations:

Understanding citation styles (e.g., MLA, APA, Chicago, IEEE Style).

Research Skills:

Using the library, internet, and organizing research materials.

UNIT – IV (7 Lectures)

Critical Analysis:

Developing arguments, evaluating sources, and reviewing literature.

Drafting and revising manuscript, addressing reviewers' queries, Annotated bibliographies or literature reviews, Final research paper.

Essential/recommended readings:

1. Birkenstein, C., & Graff, G. (2018). *They say / I say: The moves that matter in academic writing* (4th ed.). W.W. Norton & Company. (Unit-1, Unit-2, Unit-III, and Unit -IV)
2. Hayot, E. (2014). *The elements of academic style: Writing for the humanities*. Columbia University Press. (Unit-1, Unit-2, Unit-III, and Unit -IV)
3. Alred, G. J., Oliu, W. E., & Brusaw, C. T. (2019). The handbook of technical writing (12th ed.). (Unit-1, Unit-2, Unit-III, and Unit -IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.