TWO YEAR
MASTERS IN GENETICS
POST GRADUATE PROGRAMME
(Semester 1 & 2 effective from 2025)

DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS

CONTENT PAGE

About the Department

The Department of Genetics was established in 1984, as a part of the Faculty of Inter-disciplinary & Applied Sciences at the University of Delhi South Campus (UDSC). The department over the years has emerged as a strong hub for training students and for pursuing quality research in two broad areas of food and health, both with significant societal impact.

Notable scientific contributions from the department in the recent past include i) screening of 200,000 newborns for inborn errors of metabolism collaborating with 20 hospitals across the Delhi state, and generating the first ever epidemiological and genetic data for over 45 common and rare genetic disorders in the country- a good example of translational research and technology for the masses; ii) discovery of putative causal genes for a few brain disorders; iii) spearheading research on transgenic mustard for hybrid seed production, approved by the Genetic Engineering Approval Committee (GEAC) - a first such translational product from any university in India; and iii) development of non-transgenic hybrids of mustard with improved oil quality which has already reached the farmer's field.

The two-year post-graduate (M.Sc.) program, the new one-year post-graduate program and the Ph.D. program offered by the department are based on this strong foundation of research. The department enjoys a unique strength of having teaching faculty with research specialization using a range of model systems such as *Drosophila*, *Arabidopsis*, Yeast, *Dictyostelium*, and human cell-line models. The M.Sc. program is open to students with Bachelor's degree in any area of science (biological/chemical/physical) through a national level entrance test. The curriculum spread over four semesters, aims at teaching not only the basics of the science of heredity but also emerging concepts in almost all related disciplines of biology. Another distinct feature of this course is the hands-on-training imparted to the students. Emphasis is given to laboratory based learning including a small project work during the fourth semester wherein students are encouraged to conceptualize, design and perform experiments to answer a basic question related to their respective mentors' research programme, trouble shoot, interpret their data, write a report and also give an oral presentation at the end of the semester. The approach of a restrictive practical performed in a narrow time-frame is not supported, thus giving all students an opportunity to hone their skills across semesters.

Students with Master's degree in any area of sciences with an aptitude to work in the broad research programs of the department are selected for the Ph.D program based on a national level entrance test/interview and have to complete a 12 credit course before they can proceed with their experimental work. Ph.D work generally spans over five to six years followed by a rigorous thesis defense and *viva-voce* examination.

Research is an integral part of the departmental academic activity. Research programs of the faculty using cutting edge technology are focused on basic aspects of genetics, genomics and molecular biology with direct implications for crop improvement and health/disease. Specific projects under the plant sciences include high resolution mapping and marker assisted

breeding in mustard; development of pathogen using RNAi technology; understanding plant-pathogen interactions using conventional and contemporary OMICS approaches in *Arabidopsis* and Tobacco; and unraveling promoter architecture for regulation of transgene expression in plants. Biomedical research projects include identification of pre-disposing and somatic mutations in cancer using liquid biopsy and tissues, studying molecular mechanisms in cancer stemness, progression and therapy in the microenvironment; determining molecular mechanisms underlying cellular toxicity and polyQ induced neurodegeneration in Huntington's and Parkinson's diseases using *Drosophila* as a model system; studying gene-emvironment interactions, understanding cell signaling in stress and development with *Dictyostelium* as a test system; and mitochondrial genetics and ribosomal biology using yeast provide insights into important basic biological processes.

Research projects in the department have attracted generous funding support from various agencies including Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR) Anusandhan National Research Funding (ANRF, erstwhile Science and Engineering Research Board), Council of Science and Industrial Research (CSIR) and University Grants Commission (UGC). The department houses two Centres of Excellence supported by DBT and ICMR. The department has also been recognized and supported by UGC-SAP (DRS-III) and DST-FIST (level II) programs. Ph.D. scholars in the department are encouraged to avail independent fellowships and are also supported with fellowships from the university or extramural grants. A well-equipped instrumentation facility for imaging, genomics, proteomics and transcriptomics both in the department as well as the Central Instrumentation Facility of South Campus have been an exemplary support for carrying out high quality research.

Finally, contemporary and relevant syllabi for the Master's course, ongoing research projects of societal relevance together with dedicated and high performing doctoral students and faculty have enabled the department of genetics to emerge and stay in the forefront of teaching and research in different branches of Genetics in the country.

Adoption of the New Education Policy

The University has adopted the new education policy which brings flexible education system, gathering of credit points and possibility of lifelong learning into the education system. For this UGC has drafted three documents that are relevant to the PG programme being offered by the Department of Genetics.

These documents can be accessed here in their entirety:

1. The National Education Policy 2020 (https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pd
2. National Credit Framework (NCrF) (https://www.ugc.gov.in/pdfnews/9028476_Report-of-National-Credit-Framework.pdf
3. The National Higher Education Qualifications Framework (NHEQF) (https://www.ugc.gov.in/pdfnews/2990035_Final-NHEQF.pdf)
4. Post-graduate curriculum framework 2024 (PGCF 2024) based on NEP2020, as approved by Academic Council on 27th December 2024

Excerpts from the aforementioned document pertinent to the Department are shared below:

The NEP 2020 envisages flexibility in the designs and duration of Master's degree programmes: The structure and duration of master's programmes of study proposed by the NEP 2020 include:

- a 2-year Master's programme (with the option of having the second year devoted entirely to research) for those who have completed a 3-year Bachelor's programme;
- a 1-year Master's programme for students who have completed a 4-year Bachelor's degree; and
- an integrated 5-year Bachelor's/Master's programme.
- A Ph.D. programme shall require a Master's degree or a 4-year Bachelor's degree.

The National Credit Framework (NCrF) provides for Assignment, Accumulation, Storage, Transfer & Redemption of Credits. It paves way for multi-disciplinary education and empowers students through flexibility in choice of courses for choosing their own learning trajectories and programmes, and thereby choose their paths in life with appropriate career choices, including option for mid-way course corrections, according to their talents and interests.

Credit and Credit Points

'Credit' is recognition that a learner has completed a prior course of learning, corresponding to a qualification at a given level. For each such prior qualification, the student would have put in a certain 34 volume of institutional or workplace learning, and the more complex a qualification, the greater the volume of learning that would have gone into it.

(i) Credits quantify learning outcomes that are subject achieving the prescribed learning outcomes to valid, reliable methods of assessment.

(ii) The credit points will give the learners, employers, and institutions a mechanism for describing and comparing the learning outcomes achieved. The credit points can be calculated as credits attained multiplied with the credit level.

The National Higher Education Qualifications Framework (NHEQF) explains:

Table 11: Qualification type and credit requirement (given on Page 45 and 46 of NHEQF document)

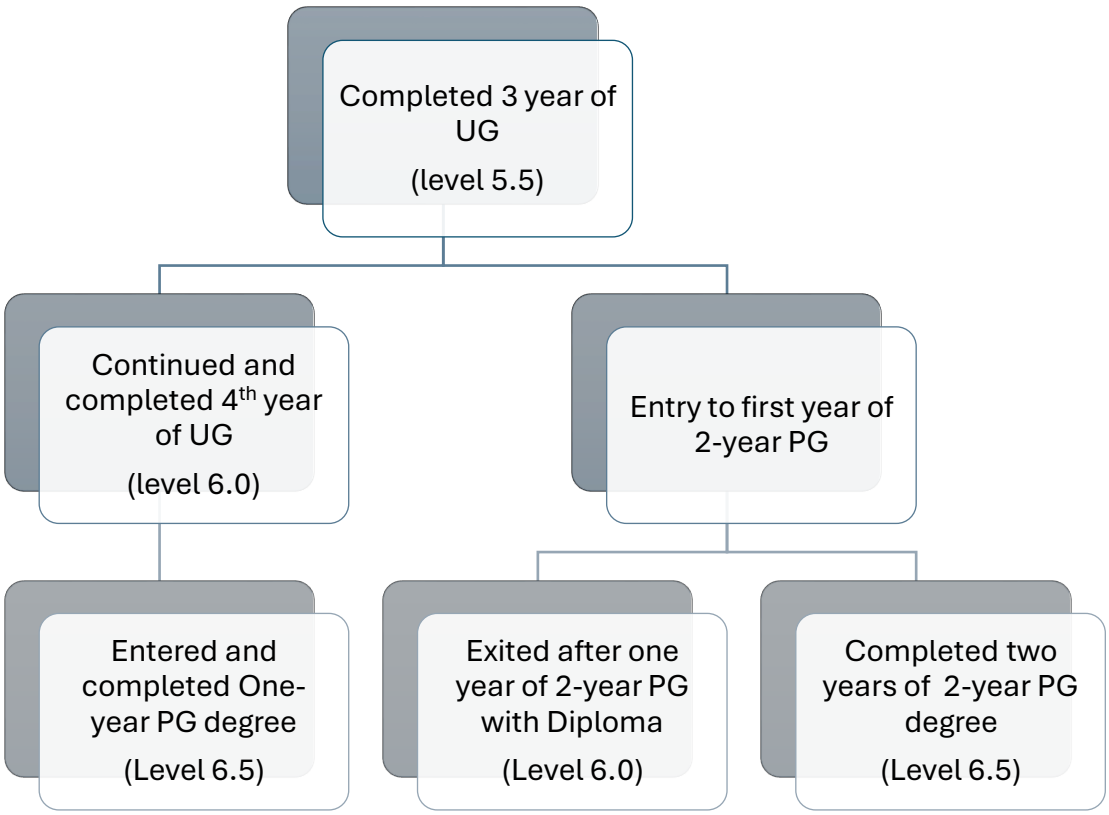
NHEQF levels	**Qualification title/nomenclature**	**Credit Requirements (Minimum)**
Level 6	Post-Graduate Diploma. For those who exit after successful completion of the first year or two semesters of the 2-year master's programme). (Programme duration: One year or 2 semesters).	40 credits
Level 6.5	Master's degree. (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: Two years or four semesters after obtaining a 3-year Bachelor's degree).	80 credits
Level 6.5	Master's degree (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: One year or 2 semesters after obtaining a 4- year Bachelor's degree (Honours/ Honours with Research).	40 credits
Level 7	Master's degree (e.g. M.E.; M.Tech. etc.) (Programme duration: Two years or four semesters after obtaining a Bachelor's degree (e.g. B.E., B.Tech.etc.).	80 credits

Table 12. Letter Grades and Grade Points (Page 46 of the NHEQF document)

Letter Grade	Grade point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (Absent)	0

Post graduate Programmes offered by the Department

From 2025, the NEP structure shall apply to the post-graduate programme of Department of Genetics. The overview of entry and exit from the 1-year and 2-year post graduate degree program is given, including the possibility of exit with diploma, as and how mandated by the University guidelines



If a 4th year UG (meeting the required eligibility) enters and completes the 2 year PG program they exit at the end of two years with Level 7 of Master's degree.

Programme Eligibility & Admission

The Department of Genetics will offer both 1 year Masters in Genetics (1Y-PG) and 2 year Masters in Genetics (1Y-PG) programmes.

Eligibility and Qualifications

Programme	Last qualifying exam	Course Eligibility	Mode of admission
1 year PG	4 year UG	Bachelor's Degree in any branch of Life Sciences/ Biology/Physical Sciences/ Chemical Sciences/ Medical Sciences/ Pharmacology from a recognized University.	As per University guidelines
2 year PG	3/4 year UG	Bachelors in any discipline of sciences or allied sciences/ BTech/ MBBS	As per University guidelines

Programme objective

TWO-YEAR MSC :

This program is aimed at graduate students from any field of science who want to pursue research careers in specialized area of biological science. The program focuses at developing strong foundational skill in various fields of genetics. In addition to fundamentals, the students are exposed to core areas in Molecular Genetics (microbial, *Drosophila,* plants and humans) as well as related areas like Biochemistry, Biostatistics, Developmental Biology, Recombinant DNA Technology and Computer Applications. Apart from the core courses, students can select few courses of their preference from a bunch of elective courses. Special emphasis is given on intensive lab practical sessions, as well as hands on for bioinformatics data analysis where every student gets a chance to independently perform the experiments and gain experience with standard molecular biology and genetic tools. Class room seminars, discussions, written tests, project work and hands on practical training are integral components of the course. In two structures, research dissertation is also included. The syllabus is updated regularly to reflect the important advances in the related field. Students are continuously evaluated during the course. Various scholarships viz., Merit Scholarship, All India Post Graduate Scholarship and Monsanto Post Graduate Scholarship are also available for the M.Sc. students. Students are encouraged to clear UGC/CSIR-NET while pursuing their M.Sc. course.

ONE-YEAR MSC

This program is aimed at graduate students from any field of science after the completion of four years of undergraduate degree and who want to pursue research careers in specialized area of biological science. A student entering this course will need to have a basic understanding of related areas of life sciences. The program focuses at developing strong foundational skill in genetics, wherein concepts of genetics will be taught using one or more model systems (microbial, *Drosophila,* plants and humans). Under the various structures, students can select few courses of their preference from a bunch of elective courses. Where the Structure has more of coursework, the Experiments in Genetics paper has been added to give the students a flavour of the strength of the department. In structures with Research projects, the students can choose elective research areas that align with their projects to gain a comprehensive skillset. Class room seminars, discussions, written tests, project work and hands on practical training are integral components of the course. The syllabus will be updated regularly to reflect the important advances in the related field. Students are continuously evaluated during the course. Various scholarships viz., Merit Scholarship, All India Post Graduate Scholarship and Monsanto Post Graduate Scholarship are also available for the M.Sc. students. Students are encouraged to clear UGC/CSIR-NET while pursuing their M.Sc. course.

Assessment of Students' Performance and Scheme of Examinations

1. English shall be the medium of instruction and examination.
2. Assessment of students' performance shall consist of end semester examination and internal assessment.
   i. For theory papers 30% of the total marks will be allotted for internal assessment. Internal assessment can be in the form of mid-term examination, assignments, quizzes or presentations including attendance (5%). The concerned teacher will inform the students of the mode of internal assessment at the beginning of the semester.
   ii. Practical papers will consist of continuing assessment (15% of the total marks) based on weekly appraisals of the work carried out by the student, a viva-voce examination (25% of the total marks) and an end of term practical examination (60% of the total marks).
   iii. Project work will be evaluated based on continuing assessment of the work by the supervisor, two presentations made by the students and a final detailed report of the work to be submitted by the student. The presentations and the report will be assessed by teachers other than the supervisor. The distribution of marks will be informed to the student at the beginning of the semester.

Definitions

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) 'Course' OR 'Paper' means a segment of a subject that is part of an Academic Programme.

(iii) 'Programme Structure' means a list of courses (Core, Elective, General Elective) that makes up an Academic Programme, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity with University rules, eligibility criteria for admission.

(iv) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi) 'General Elective' means an elective course which is available for students of all programmes, including students of the same department. Students of other Departments will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into % marks is given in the Transcript.

Quick References For Navigating Through The Courses

Often used abbreviations:
2Y-PG : 2 year post graduate programme
1Y-PG : 1 year post-graduate programme
DSE : Discipline specific elective
DSC : Discipline specific core
2CC or 2c : 2 credit course
RP or R : Research project
TR : Tools for Research
GE : General Elective
S1 : Structure 1
S2 : Structure 2
S3 : Structure 3
Th : Theory
P : Practical
T : Tutorial
E : elective
C : core

Example of a representation of course content:

The following representation is of the paper 'XYZ' as shown on the title page where its detailed course content is given, under the Structure 1, Coursework (marked as S1) offered in Semester 3. In this representation the course of 2 year post graduate program is given (marked as 2Y-PG)

SEMESTER 1; S1 **GEN-XXX** 2Y-PG

XYZ course/paper

This paper may be also present in Structure 2 or 3 also and its content will be represented again along with all other papers

MSC GENETICS – TWO YEAR DEGREE PROGRAM

(approved)

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 courses (2c) 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 (Th), 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 Types 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.

The approved syllabus for M.Sc. Genetics (Semester I and II) has been structured as follows:

Sem 1&2	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	3	2 (2DSE+0GE; 1DSE+1GE)	1	0	**6**
Credits	12	8	2	0	**22**
Student needs to complete 12+8+2+0 = 22 credits in each semester					

SEMESTER 1 (2Y-PG)

PAPERS OFFERED						
Course Code	**Type**	**Title**	**Credits**	**Credit distribution**		
				Th	P	T
DSC-GEN-101	DSC	Biological Processes and Patterns of Inheritance	4	3	1	0
DSC-GEN-102	DSC	Genes, Genomes and Chromosomes	4	3	1	0
DSC-GEN-103	DSC	Experiential learning in Genetics - I	4	0	4	0
DSE-GEN-104	DSE	Molecular Biology	4	3	0	1
DSE-GEN-105	DSE	Cell Biology	4	3	0	1
DSE-GEN-106	DSE	Enzymology and Metabolism	4	3	0	1
GE-GEN-110	GE	Genetics in Crop Improvement	4	3	0	1
2C-GEN-111	2CC	Statistical Analysis in Biology	2	1	1	0
Distribution of total theory, practical and tutorial in Sem 1			22	13	7	2

SEMESTER 2 (2Y-PG)

PAPERS OFFERED						
Course Code	**Type**	**Title**	**Credits**	**Credit distribution**		
				Th	P	T
DSC-GEN-201	DSC	Regulation of Gene Expression	4	3	1	0
DSC-GEN-202	DSC	Recombinant DNA Technology	4	3	1	0
DSC-GEN-203	DSC	Experiential learning in Genetics-II	4	0	4	0
DSE-GEN-204	DSE	Development Biology	4	3	0	1
DSE-GEN-205	DSE	Immunology & Immunogenetics	4	3	0	1
DSE-GEN-206	DSE	Mitochondrial Biology & Connection to Cell Physiology	4	3	0	1
GE-GEN-210	GE	Genetics in Everyday Life: From DNA to Society	4	3	0	1
2C-GEN-211	2CC	Microscopy and Imaging	2	1	1	0
Distribution of total theory, practical and tutorial in Sem 2			22	13	7	2

Notable value addition in course types offered by Department of Genetics

The M.Sc. Genetics program in Semesters I and II is carefully structured to balance theoretical understanding with practical application.

The 4 Credit Practical DSC

One of our DSC course is a 4 credit experimental course. Over the years, the Department of Genetics has moved away from conventional, stand-alone "boxed" experiments toward a more open-ended, inquiry-driven pedagogical approach. Our emphasis is not on teaching protocols or fixed techniques but on encouraging students to explore, experiment, and question.

This often leads to surprising observations, fostering discussions and deeper understanding. Such experiences spark curiosity, build scientific temper, and nurture the courage to question—an essential quality for any researcher or professional. These practical modules are designed as continuous investigative experiences, not just technical routines. Through this process, students also gain essential research skills such as data collection, analysis, scientific writing, and presentation. The goal is to help students understand core concepts and begin thinking and working like scientists.

Role Of Tutorials In Our Curriculum

Tutorials in our curriculum are not just meant for clearing doubts. While, they remain a space for one to one interactions, they been designed in a manner that they can be used to discuss important scientific discoveries and encourage open debates. Students get a chance to read, present and discuss key research papers, helping them understand how scientific ideas are developed and tested over time. They will be not only be used to discuss important scientific discoveries and papers but also include screening of selected videos like expert talks or recordings of biological processes. Some of the tutorials also feature live demonstrations of experiments or biological concepts in the classroom. Together, these elements make tutorials a vital part of our curriculum, helping students think critically, communicate effectively, and engage with the scientific process.

The 2 Credit Skill Based Papers

The skill-based courses in line with the NEP emphasis on experiential, hands-on learning along with academic knowledge. These subjects equip students with essential tools for scientific inquiry—biostatistics trains them in quantitative reasoning and data analysis using software platforms relevant to modern biology, while microscopy builds a skill important in the research field and for studying many biological processes. Both have strong cross-disciplinary relevance, contributing to fields as diverse as genetics, public health, biotechnology, environmental science, and clinical research. By working with real data, instruments, and analytical methods, students will develop competencies that are directly applicable in research and industry settings, enhancing both their academic foundation and career readiness.

COURSE DETAILS

ALL PAPERS OFFERED IN SEMESTER 1 OF THE 2Y-PG

SEMESTER 1 **DSC-GEN-101** 2Y-PG

Biological Processes and Patterns of Inheritance

***Course Objective**: The undergraduate genetics course typically focuses on inheritance patterns through ratios and numbers, often presented as an isolated subject without connections to broader biological processes. This course aims to bridge that gap by linking previously learned concepts to various biological mechanisms, fostering a deeper understanding and greater conceptual clarity for students. The syllabus reflects the various areas that will be covered, not necessarily in a linear fashion but by cross-referencing between units to enhance integrated learning. This is a primer to an advanced course to be offered in semester III. The experiential learning included in this paper would lead to appreciation of organisms and develop observational skills of learners.*

	Total	Theory	Practical	Tutorial
Credits	4	3	1	0
Hours	75	45	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	75	3
Practical	25	3

Unit	Unit Name	Hours
Theory		
I	Biological Processes	10
II	Variation: Key to Inheritance Biology	8
III	Inheritance patterns	24
IV	The Good, The Bad, The Ugly	3
Practical		
I	Introduction to Model Organisms - Observation and Handling	20
II	Tracking Variations- Identifying Mutant Phenotypes	10

Course Outcome: On completing 'Biological Processes and Patterns of Inheritance' the students would have:

- Developed a holistic understanding of genetic principles, inheritance patterns, genetic variation, and molecular mechanisms governing phenotypic expression, linking classical concepts to broader biological processes.
- Analysed genetic variation and its role in Inheritance by exploring mutation sources, allele interactions, recombination, and the use of genetic markers to track variations, and diversity in populations.
- Critically examined the impact of genetics on medicine, agriculture, and society.
- Learnt the nuances and developed appropriate skills of handling and maintaining organisms for genetic analysis.
- Developed keen observational powers, a key to being a good geneticist

Content (Theory)

I. Biological Processes

- Life Cycles of Organisms
    - A comparative overview with examples from microbes, plants and animals with reference to genetic analysis
- Cellular Basis of Inheritance
    - Mitosis and Meiosis: A comparative analysis as mechanisms ensuring genetics consistency versus genetic diversity
    - Fertilization: restoring diploidy, introducing variability through gamete fusion.
    - A review of cell structure and developmental processes with reference to inheritance patterns
- Molecular basis of phenotypic expression
    - Dominant, recessive, co-dominant, incomplete dominant phenotypes
    - Biochemical pathways as foundation to phenotypic outcomes due to gene interactions
    - Influence of environment
    - Pleiotropy, penetrance and expressivity.

II. Variation: Key to Inheritance Biology

- Sources
    - Mutations: spontaneous versus induced including molecular basis
    - Defining alleles including test for allelism
    - Role of independent assortment and recombination in genetic diversity
    - Horizontal gene transfer
- Tracking variations
    - Phenotypic versus molecular markers
    - Isozymes, allozymes and DNA markers with examples (basic concepts not techniques)
    - Genetic diversity in population: the power of SNPs

III. Inheritance patterns

- Mendel's experiments
    - History including the lesser-known contributions of Festetics
    - Experimental design with observations that extend beyond Mendel's classical "Laws."
    - From Mendel's 'characters' to genes – an example of forward genetics
- Chromosomal behaviour and inheritance patterns
    - Segregation
    - Independent assortment
    - Linkage with an introduction to the concept of genetic maps
    - Application of probability and statistics in genetic analysis
- Analysing inheritance patterns
    - Comparison between diploids and haploids
    - Crosses versus pedigree analysis
    - Single gene inheritance patterns
    - Patterns due to gene interaction
    - Polygenic inheritance and Quantitative traits
    - Cytoplasmic and maternal inheritance

IV. The Good, The Bad, The Ugly

- The Good:
    - Genetic Disease Screening and Prevention
    - Personalized Medicine
    - Improvements in Agriculture
- The Bad:
    - Genetic discrimination
    - Unintended consequences of gene editing
- The Ugly:
    - Eugenics and Genetic Purity Movements
    - Designer Babies and Ethical Dilemmas
    - Lysenkoism and Political Suppression of Genetics

Content (Practical)

I. **Introduction to Model Organisms - Observation and Handling:** Hands-on training in identifying, observing, and safely handling commonly used model organisms for genetic analysis exemplified by *E. coli*, phages, yeast, *Dictyostelium*, *Arabidopsis*, and *Drosophila*. Emphasis on learning to distinguish different life stages, understanding their wild type phenotypes, and becoming familiar with the laboratory setups required for their growth, development and maintenance.

II. **Tracking variations – identifying mutant phenotypes:** Using *Drosophila* as a model students would be given experiential training to describe mutant phenotypes and identify them using AI tools and Drosophila databases.

Suggested Reading

1.	Introduction to genetic analysis	Griffith AF et al,	WH Freeman &co
2.	Concepts of Genetics-	Klug WS &Cummings MR,	Prentice -Hall
3.	Genetics - a conceptual approach	Pierce BA	WH Freeman &Co
4.	Genetics Analysis	Phillip Meneeley	Oxford press

SEMESTER 1 **DSC-GEN-102** 2Y-PG

Genes, Genomes and Chromosomes

Course Objective: *This paper has been designed to provide fundamental and advanced aspects of chromosome biology, genome organization, concept and mapping of genes, and outshoots. The students are expected to develop a holistic notion about the dynamic nature of chromosomes and their influence in regulating various aspects of cellular functioning and the organism as a whole. Emphasis would be given to explain the topics with the help of interactive classroom sessions including classical experimental strategies, examples from different model organisms, and contemporary genetic approaches and methods.*

	Total	Theory	Practical	Tutorial
Credits	4	3	1	0
Hours	75	45	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	75	3
Practical	25	3

Unit	Unit Name	Hours
Theory		
I	Chromatin/ chromosome structure, organization, and anomalies	15
II	Concept of gene and genome organization	10
III	Methods to study chromosomes and genes	6
IV	Cytogenetic aspects of cell division	8
V	Sex determination and dosage compensation	6
Practical		
I	Visualizing chromosomes	20
II	Analysing chromatin	10

Course Outcome: On completing 'Genes, Genome & Chromosomes' the students would have:

- Understood chromosome structure and organization and gained knowledge of chromatin architecture, chromosome morphology, functional chromosomal domains, and the impact of structural anomalies on cellular function.
- Developed an understanding of gene and genome organization by examining gene structure, genome complexity, repetitive DNA, transposable elements, and their roles in genome evolution and function.
- Learnt cytogenetic techniques and sex determination and explored chromosome analysis methods, cell division regulation, chromosomal non-disjunction, and mechanisms of sex determination and dosage compensation
- Been equipped with practical training in chromosome and chromatin analysis, enabling them to prepare, stain, and interpret cytological samples and understand chromatin organization in somatic and germ cells.

Content (Theory)

I. Chromatin/ chromosome structure, organization, and anomalies

- Histones, DNA, nucleosome morphology and higher-level organization
- Functional states of chromatin and alterations in chromatin organization.
- Metaphase chromosomes**:** centromere and kinetochore, telomere and its maintenance, Holocentric chromosomes, Heterochromatin and euchromatin, position effect variegation
- Chromosomal domains (matrix, loop domains) and their functional significance, Nuclear speckles, Long-range chromosomal interactions, Chromatin remodeling.
- Polytene and lampbrush chromosomes, and their biological significance.
- Overview of numerical and structural alterations, and their impact on cellular functioning and development, induced chromosomal aberrations in somatic cells.

II. Concept of gene and genome organization:

- Conventional and modern views, fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families.
- Viruses and prokaryotes, Eukaryotes- Organization of nuclear and organellar genomes, C-value paradox, Repetitive DNA - satellite DNAs and interspersed repeat DNAs.
- Transposable elements- Barbara McClintock's experiment of maize, Autonomous and non-autonomous transposons, clonal selection, retrotransposons, LINES, SINES, Alu family, Application of transposons in mutagenesis, genome mapping and evolution.

III. Methods to study chromosomes and genes

- Short-term (lymphocyte) and long-term (fibroblast) cultures, chromosome preparations, karyotyping, banding, chromosome labeling, in situ hybridization, chromosome painting, comparative genome hybridization, somatic cell hybrids and gene mapping, and single cell omics.

IV. Cytogenetic aspects of cell division:

- Chromosome labeling and cell cycle analysis,
- overview of mitosis and meiosis, sister chromatid cohesion remodeling, regulation of exit from metaphase, chromosome movement at anaphase, genetic control of meiosis
- Non-disjunction of chromosomes

V. Sex determination and dosage compensation

- Genetic determination of sex in *Caenorhabditis elegans*, *Drosophila melanogaster*, mammals and flowering plants.
- Various approaches of dosage compensation. Genetic control of dosage compensation in *Caenorhabditis elegans*, *Drosophila melanogaster*, and mammals.
- Lyon's hypothesis, genetic control of X-chromosome inactivation, XIST and TSIX

Content (Practical)

I. Visualizing chromosomes: This unit deals with the structural and functional aspects of chromosomes using various model organisms and cytogenetic techniques.

- **Preparation and analysis of polytene chromosomes :**
  - Dissection and preparation of polytene chromosome squashes from salivary glands of third instar *Drosophila melanogaster* larvae.

- Identification of chromosome arms based on characteristic banding patterns.

- **Study of Mitosis and Meiosis :**
  - Observation and staging of mitosis in onion (*Allium cepa*) root tip cells and in onion flower bud cells.
- **Human karyotype construction and chromosomal aberrations**
  - Construction of human karyotypes from provided metaphase spreads.
  - Identification and interpretation of chromosomal aberrations (numerical and structural anomalies).

II. Analysing chromatin: This unit focuses on chromatin structure, nuclear organization, and chromatin-associated features using histological and fluorescence techniques.

- **DAPI Staining of Chromatin in Drosophila**
  - Fluorescent staining using DAPI (4',6-diamidino-2-phenylindole) to visualize chromatin in somatic and germ cell nuclei of *Drosophila* for a comparative analysis.
- **Study of Sex Chromatin (Barr Body)**
  - Slide preparation and study of the sex chromatin in human somatic tissues

Suggested Reading

1.	Essential Cell Biology	Alberts B *et al.*	Garland Publishing
2.	Molecular Biology of the Cell	Alberts B *et al.*	Garland Publishing
3.	The Eukaryotic Chromosome	Bostock CJ & Summer AT	Elsevier
4.	The Chromosome	Harrison HJS &Flavell RB	Bios
5.	Advanced Genetic Analysis	Hawley RS & Walker MY	Blackwell Publishing
5.	Structure & Function of Eukaryotic Chromosomes	HennigW	Springer

SEMESTER 1 **DSC-GEN-103** 2Y-PG

Experiential learning in Genetics - I

***Course Objective**: This course follows an experiential learning approach, promoting "learning by doing" as emphasized in the National Education Policy (NEP). Instead of performing separate experiments, students engage in hands-on activities that encourage curiosity and problem-solving. They learn to ask questions, design experiments, test different methods, analyse mistakes, troubleshoot issues, and repeat experiments when needed. Additionally, they develop skills in data collection, analysis, scientific writing, and presentation. This module helps students gain a deeper understanding of concepts while thinking and working like scientists. This paper has two units working with bacterial and plant systems, experiencing the power of genetical and biochemical approaches, respectively.*

	Total	Theory	Practical	Tutorial
Credits	4	0	4	0
Hours	60	0	120	0

Proposed Evaluation		
Exam	**Marks**	**Hours**
Practical	100	6

Unit	Unit Name	Hours
Practical		
I	The power of mutagenesis: an analysis using *E. coli*	60
II	The power of biochemical techniques: Purification and Characterization of Acid Phosphatase from Moong Dal	60

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

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

Content (Practical)

I. The power of mutagenesis: an analysis using *E. coli*

Introduction: This module introduces students to UV mutagenesis in *E. coli*, providing hands-on experience in inducing, identifying, and analysing mutations. It allows students to connect different concepts from microbial genetics, metabolic regulation, and molecular biology with practical applications, giving them a holistic understanding. Through mutant screening, biochemical assays, and data analysis, students will develop key skills in experimental design, troubleshooting, and interpretation, preparing them for advanced genetic studies. The key experiments are as follows:

- **Preparation of E. coli culture**:
  Grow wild-type bacterial culture to exponential phase for UV exposure
- **UV Mutagenesis protocol:**
  Expose bacterial culture to calibrated UV doses to induce random mutations
- **Recovery and plating on different media:**
  Plate treated cultures on media designed to screen for biochemical mutants—e.g., inability to metabolize lactose (MacConkey agar), auxotrophs (minimal media lacking specific amino acids), or altered pH indicators for acid/base production
- **Mutant screening and selection:**
  Identify mutants based on changes in colony colour, growth patterns, or response to biochemical indicators (e.g., enzyme-substrate colour shifts)
- **Enzyme assays (Optional Extension)**: <u>can be carried over to next semester</u>
  Perform basic enzyme activity assays (e.g., β-galactosidase) to assess functional consequences of mutations
- **Quantification and analysis**:
  Calculate mutation frequency, assess phenotypic ratios, and interpret data to predict affected pathways or genes
- **Confirmation and characterization:**
  Re-test selected mutants to confirm stability of biochemical phenotype and rule out false positives
- **Discussion and Troubleshooting:**
- Collate data, analyse experimental challenges and variability, present data and discuss implications of findings, and reflect on how mutations reveal insights into biochemical systems.

II. The power of biochemical techniques: Purification and Characterization of Acid Phosphatase from Moong Dal

Introduction: This project offers a structured approach to biochemical experimentation, integrating techniques into a cohesive workflow rather than treating them as isolated tasks. Focusing on the extraction, enzymatic characterization, purification, and analysis of acid phosphatase from moong dal sprouts, it equips students with hands-on experience in protein handling, enzyme kinetics, and purification strategies, deepening their understanding of core biochemical principles. The key experiments are as follows:

- **Buffer systems and pH optimization:**
  Prepare acetate buffer (pH 5.0) to apply concepts of Henderson-Hasselbach equations taught to them in theory classes and used to maintain enzyme stability
  Plot titration curves for acetic acid and sodium dihydrogen phosphate (NaH_2PO_4) to understand workings of buffer systems
- **Enzyme extraction and activity assay:**
  Extract acid phosphatase from moong dal sprouts
  Determine the molar extinction coefficient of p-nitrophenol (PNP), the product generated from enzymatic activity measurements
  Assay acid phosphatase activity using PNPP as substrate and calculate its specific activity
- **Protein estimation and enzyme kinetics**
  Estimate total protein content
  Study the effect of varying substrate concentration on acid phosphatase activity
  Generate a Michaelis-Menten curve and determine Km and Vmax values
- **Protein purification**
  Isolate lysosomes from moong dal extracts using differential centrifugation and observe the enrichment of Acid Phosphatase
- **Data collation, analysis, interpretation and presentation**
  Compare Acid Phosphatase enzyme activity in crude vs. purified fractions.
  Calculate purification fold and enzyme yield.
  Discuss experimental challenges, errors, and possible improvements.

Molecular Biology

***Course Objective**: From a geneticist's point of view, the understanding of informational molecules, such as DNA, RNA, and proteins is central as they provide information on life and its processes. This paper deals with the structural and informational molecules, and their role in information transfer. This paper will focus on basic processes of copying, restructuring, readout and decoding of genetic information both in prokaryotes and eukaryotes with emphasis on discussions of seminal experiments and discoveries. Detailed mechanisms of each process will be discussed with components of machinery, factors and steps involved*.

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	DNA-discovery, forms and topology	3
II	DNA replication	12
III	Recombination and Repair	8
IV	RNA World	2
V	Transcription	10
VI	Translation	10
Tutorials		
	Various modalities as given below	15

Course Outcome: On completing 'Molecular Biology' the students would have:

- Understood DNA topology, replication mechanisms, recombination, and repair processes, along with their roles in genomic stability and disease.
- Learnt RNA and transcription and developed an understanding about RNA types, transcription mechanisms in prokaryotes and eukaryotes, gene regulation, and post-transcriptional modifications.
- Gained insights into translation and protein processing by analyzing concepts of genetic code, translation mechanisms, ribosome function, and post-translational modifications essential for protein synthesis
- Gained confidence in analyzing data from classical and contemporary research papers on these concepts

Content (Theory)

I. DNA -discovery, forms and topology

- Tracing the path-breaking discoveries and seminal experiments on the road to identification of genetic material and its function (1869-1953)
- DNA structure and forms; Difference between RNA and DNA; Stability; Function of A, B and Z type
- DNA topology, domain organization in prokaryotes and eukaryotes
- Negative and Positive supercoiling, Types and function of Topoisomerases
- DNA conformation and complexity

II. DNA Replication

- Origin of replications : Structure, sequence, types in various organisms, Licensing and firing, methods of identifying origin of replication
- Assembly and function of the Replisome : Models of replication, molecular composition, mechanism, directionality & error rate
- Overcoming the end replication problem: Telomeres, telomerases and complexes
- Regulation of DNA replication
- Syncing with cell cycle, Kinase mediated regulation of DNA replication, negative and positive regulation of DNA replication in prokaryotes and eukaryotes

III. Recombination and Repair

- Types of DNA damage
- Molecular Mechanisms of different types of DNA repair in prokaryotes and eukaryotes
- Recombination : Types, formation and resolution of recombinants in Homologous, non-homologous end-joining (NHEJ), recombinational repair, meiotic recombination
- Recombination events in biology and experimental systems
- Genomic instability and diseases associated with faulty repair and recombination

IV. RNA

- Types of RNA, role of RNA in information transfer, Ribozymes, RNA world

V. Transcription in prokaryotes and eukaryotes

- Transcription in Bacteria; RNA polymerase structure, Promoter structure, initiation, elongation and termination
- Transcription in eukaryotes; Multiple forms of eukaryotic RNA polymerases, promoters, enhancers and silencers
- Transcription factors & activators; DNA binding motifs, independence of the domains of activators
- Post-transcriptional events
- Other RNA processing events such as *trans*-splicing, RNA editing

VI. Translation in prokaryotes and eukaryotes

- Mechanism of translation; Initiation, elongation, termination
    - Aberrant termination, use of stop codons to insert unusual amino acids
- The genetic code- nonoverlapping codons, no gaps in the code, breaking the code, unusual base pairs between codon and anticodon, codon usage
- tRNA structure, recognition of tRNA by aminoacyl-tRNA synthetase, proofreading and editing by aminoacyl-tRNA synthetase
- Ribosome: composition, structure and assembly

- Posttranslational; Folding of nascent proteins, Release of ribosomes from mRNA, Covalent modification

Content (Tutorial)

- Addressing **Individual queries** on class concepts
- Discussing **research papers** on seminal work in the field exemplified by the following
    - Meselson M, Stahl FW. The replication of DNA in Escherichia coli (1958)
    - Watson, J., Crick, F. Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid. (1953)
    - Gros F., Hiatt H., Gilbert W., Kurland C.G., Risebrough R.W. and Watson J.D., Unstable Ribonucleic Acid Revealed by Pulse Labelling of *Escherichia coli* (1961).
    - Brenner S., Jacob F. and Meselson M, An Unstable Intermediate Carrying Information from Genes to Ribosomes for Protein Synthesis, (1961).
- Discussing **relevant video content** exemplified by
    - "Photograph 51" -a play by Anna Ziegler (https://youtu.be/H7BgQTpL7x4?si=c--iZzQy-KJ0UpUh)
    - The Structural History of RNA Polymerase Transcription Machinery - Nobel Laureate Dr. Roger Kornberg (https://www.youtube.com/watch?v=XkJfo0yJtqI)
- Performing **Class exercises** such as
    - generating right handed and left handed DNA molecules with mimics to understanding and record changes in linking number
- **Analysing results** of research papers as quiz based class discussion such as Identification of origin of replication; isolation of the components of transcription and translation machinery and others
- **Discussion** on use of radioactivity and its aftermath on scientists; precautions
- Exploring **digital resources** for understanding scope of experimental model systems such as
    - Jackson Laboratory with Cre-lox mice- discussion and video(https://youtu.be/ibNmCZqzmoo

Suggested Reading

1.	Molecular Biology of the Cell	Alberts B et al	Garland Science
2.	Molecular Biology of the Gene	Watson J. D. et al	C S H L Press
3.	Genes X	Krebs, J. E et al	Jones & Bartlett Publishers
4.	Cell and Molecular Biology: Concepts and Experiments	Karp G.	Wiley
5.	The Cell: A Molecular Approach	Cooper G. M	Sinauer Associates
6.	Related papers as shared in class		

SEMESTER 1 **DSE-GEN-105** 2Y-PG

Cell Biology

Course Objective: *The course is geared to impart a basic understanding of cell structure and organization, bioenergetics, transport of proteins and RNA to and fro in eukaryotic organelles, checks and balances during stress, signal transduction, crosstalk between basic processes and cell cycle regulation, regulated protein destruction and basics on programmed cell death. Some of these will be discussed as a part of off-lecture series, demonstrations and discussions listed under tutorial.*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Cell structure and Organization	8
II	Cellular energetics	6
III	Trafficking of biomolecules	9
IV	Cell cycle regulation & checkpoints	11
IV	Cell signalling & cellular proteolysis	11
Tutorials		
	Various modalities as given below	15

Course Outcome: On completing 'Cell Biology' the students would have:

- Developed a thorough understanding of cell Structure and organization by learnings on cell architecture, organelles, and membrane dynamics.
- Learnt about cellular processes and regulation including energy production and cell cycle control.
- Acquired knowledge on biomolecular trafficking with insights on the mechanisms of protein and mRNA transport, protein sorting via the secretory pathway, endocytosis, and the regulation of cholesterol homeostasis.
- Gained insights into signalling and proteolysis wherein cell signaling, checkpoints, and protein degradation mechanisms would be covered

Content (Theory)

I. Cell structure and Organization

- Protein structure, Plasma membrane; Fluid mosaic model
- Nuclear organization
- Information compartment- ER, Golgi, Mitochondria, Chloroplast, Cytoskeleton

II. Cellular Energetics

- Energy rich compounds, ATP synthesis, thermodynamics of cellular reaction

III. Trafficking of biomolecules

- Protein and mRNA transport to and ~~fro~~ from nucleus
- Protein transport into ER and Mitochondria
- Protein sorting via secretory pathway
- Endocytosis
- Unfolded protein response;
- Cholesterol homeostasis- cellular transport, regulation of biosynthetic genes.

IV. Cell cycle regulation & checkpoints

- Overview of the cell cycle, cell cycle control system
- Role of cyclins and cyclin-dependent protein kinases (Cdks)
- Cdk phosphorylation and dephosphorylation,
- Cdk inhibitors
- Checkpoints and cellular responses

V. Cell signaling & cellular proteolysis

- Basic elements of cell signaling systems, Signal molecules and their receptors
- Signal transduction by G protein-coupled receptors, G protein cycle
- Role of intracellular messengers
- Protein-tyrosine phosphorylation as a mechanism for Signal transduction
- The cAMP-PKA pathway
- The Ras-MAP Kinase pathway
- Crosstalk among different signaling pathways
- Programmed cell death, Ubiquitin pathway, Proteosomes

Content (Tutorial)

- Addressing **Individual queries** on class concepts
- Discussing **research papers** on seminal work in the field exemplified by the following:
    - Simon SM, Blobel G. A protein-conducting channel in the endoplasmic reticulum. Cell. 1991 May 3;65(3):371-80.
    - Walter P, Blobel G. Purification of a membrane-associated protein complex required for protein translocation across the endoplasmic reticulum. Proc Natl Acad Sci U S A. 1980 Dec;77(12):7112-6.
- Discussing **relevant video** content exemplified by
    - Günter Blobel's work on protein trafficking **(**https://www.nobelprize.org/prizes/medicine/1999/blobel/lecture/)

- Paul Nurse's work on cell cycle regulation (https://www.nobelprize.org/prizes/medicine/2001/nurse/lecture/)
- Dictyostelium Chemotaxis towards cAMP (https://youtu.be/lFx73Wq2QSQ?si=n5Ck7O7NTf-K_I_A)

- Discussing foundational experiments in class discussion such as:
  - Heterokaryon experiments for diffusible regulatory molecules during cell cycle
  - Identification of receptor for a particular signal
  - Historical background for nitric oxide (NO) as a gaseous signal
  - Genetic analysis to isolate cyclin partner for Cdk
  - Effect of MPF activity on early and late mitotic processes
  - Regulated protein degradation for survival

Suggested readings

1.	Molecular Cell Biology	Lodish H*et al.*	W. H. Freeman
2.	The World of the Cell	Becker WM *et al.*	Benjamin Cummings
3.	Biochemical Calculation	Seigel IH	Wiley
4.	Cell and Molecular Biology: Concepts and Experiments	Karp G.	Wiley
5.	Molecular Biology of the Cell	Bruce Albert*set al.*	Garland

SEMESTER 1 **DSE-GEN-106** 2Y-PG

Enzymes and Metabolism

Course Objective: *Life on this earth has evolved through a set of simple biochemical reactions, which has subsequently given rise to specific cell types. Biochemistry and metabolic pathways are fundamental to life, influencing energy production, nutrient metabolism, and overall health. This course explores enzymatic function, inhibition, and regulation emphasizing on key biochemical pathways such as glycolysis, the TCA cycle, and oxidative phosphorylation, among others. The integral role in daily life—from diet and exercise to disease prevention and health maintenance, some of which will be discussed as a part of off-lecture series and discussions listed under tutorial.*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Enzyme: Structure, types, kinetics with examples	10
II	Biomolecules and Nutrition	7
III	Carbohydrate metabolism	10
IV	Lipid metabolism	10
IV	Overview of Protein metabolism	6
V	Metabolic diseases	2
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing 'Enzymology & Metabolism ' the students would have:

- Analysed enzyme function and metabolism and understood the role of enzymes as biocatalysts, their mechanisms, specificity, kinetics, and regulatory processes, including inhibition and allosteric control.
- Learnt about an integration of biomolecule processing and energy metabolism particularly how macronutrients (carbohydrates, lipids, and proteins) are metabolized and utilized
- exploring key pathways such as glycolysis, the TCA cycle, oxidative phosphorylation, and lipid metabolism, along with their hormonal regulation.
- Gained insights into metabolic Disorders and health Implications such as metabolic diseases like diabetes and obesity, inborn errors of metabolism, and the impact of nutrition and metabolic states (e.g., exercise, starvation) on overall health.

Content (Theory)

I. Enzymes

- Biocatalysts : why do they exist in nature? ; Properties of an enzyme ; Mechanism of a catalytic reaction; Specificity and kinetics of a reaction
- Inhibition of enzyme activity- Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive inhibitors
- Regulation of enzyme activity; Allosteric enzymes

II. Biomolecules and Nutrition

- Chemical bonds
- Digestion and Uptake of Biomolecules
- Source of the building block matters! Evolving concepts on health
- Role of organs in metabolism
- State of rest, exercise and starvation – an overview
- Nutrition and gut microbiome; learnings from ayurveda and Charak Samhita

III. Carbohydrate metabolism

- Redox reactions
- Types of Glucose Transporters and their specific actions
- Metabolism of carbohydrates
- Glycolysis, rate-limiting steps, regulation of glycolysis
- TCA cycle, role of acetyl-CoA & malonyl-CoA
- Oxidative phosphorylation, shuttle systems and Electron transport chain
- Hormonal Regulation of carbohydrate metabolism – Glycogenolysis, Glycogenesis and gluconeogenesis
- Warburg's effect in cancer

IV. **Lipid metabolism**

- Break down (lipolysis) : beta oxidation in mitochondria
- Synthesis (lipogenesis): structure and function of multi-enzyme complex Fatty acid Synthase
- Ketone body breakdown and synthesis
- Cholesterol synthesis

V. Overview of protein metabolism

- Catabolism of proteins
- Synthesis of non-essential amino acids and polypeptide chain

VI. Metabolic Diseases

- Diabetes, Obesity, Cancer, Inborn errors of metabolism

Content (Tutorials)

- Addressing **Individual queries** on class concepts
- Discussing **seminal work** in the field using Nobel prize lectures exemplified by the following

    - The engineer Francis H. Arnold who won the Nobel prize in Chemistry 2018 for her work on directed evolution of enzymes (https://youtu.be/6hOZ5e0g9Uo?si=i702AivmmR6IxY1W).
    - Discovery of insulin lecture by Prof Ronald Kahn (https://youtu.be/W9YlXLN-wGU?si=SOW9vIA1z4ZzWaLB)
- **Performing Class exercises** such as
    - Calculation and recording of GTPase enzymatic activity i.e. hydrolysis of GTP to GDP
    - Calculation of Equilibrium dissociation constants for GTPase for GDP and GTP)
- **Analysing results of research papers** as quiz based class discussion such as
    - Lin B, Covalle KL, Maddock JR. 1999. The Caulobacter crescentus CgtA Protein Displays Unusual Guanine Nucleotide Binding and Exchange Properties. J Bacteriol 181:. (https://doi.org/10.1128/jb.181.18.5825-5832.1999)
    - Röder PV, Geillinger KE, Zietek TS, Thorens B, Koepsell H, Daniel H. The role of SGLT1 and GLUT2 in intestinal glucose transport and sensing. PLoS One. 2014 Feb 26;9(2):e89977.
- **Discussions** on use of knowledge on metabolism with examples from
    - Michael Phelps - physical training and endurance of athletes; 1000 calories and cold thermogenesis
    - Anna Hazare – effects of starvation
    - Weight loss and gain – sustaining diets
- **Exploring digital resources** for understanding scope of experimental model systems such as
    - Generation of a mighty-mouse - Hanson RW, Hakimi P. Born to run; the story of the PEPCK-Cmus mouse. Biochimie. 2008 Jun;90(6):838-42. & Supermouse official video by Case Western University (https://youtu.be/4PXC_mctsgY?si=_dzXn3A1_O-iLm2u)

Suggested readings

1.	Principles of Biochemistry	Lehninger*et al.*	W. H.Freeman
2.	Biochemistry	Devlin TM	Wiley-Liss
3.	Biochemistry	Berg JM, TymoczkoJL&Stryer LT	W. H.Freeman
4.	Biochemical Calculation	Seigel IH	Wiley
5.	Harper's Biochemistry	Kennelly PH et al	McGraw Hill

SEMESTER 1 **GE-GEN-110** 2Y-PG

Genetics in Crop Improvement

***Course Objective**: Students will understand the basic concepts of crop improvement and how germplasm sources along with conventional and modern crop improvement methods can help achieve goals of food security.*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Introduction	5
II	Sources of germplasm for breeding	4
III	Conventional methods for crop improvement	12
IV	Modern methods of crop improvement	12
V	Application of genetic transformations in crop improvement	12
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing 'Genetics in Crop Improvement' the students would have:

- Gained insights into crop Improvement and breeding strategies and understood the fundamentals, history, and methods of crop improvement, including conventional breeding techniques for self- and cross-pollinated plants.
- Analyzed modern genetic approaches such as molecular breeding, marker-assisted selection, genome-wide studies, and advanced techniques like genomic selection and speed breeding.
- Developed an understanding of genetic transformation and biosafety and explored transgenic traits in crops, their applications, and the biosafety concerns associated with genetic modifications.
- Been enthused through invigorating discussion to take up research in crop improvement

Content (Theory)

I. Introduction
- History, Scope and Basic concepts

II. Sources of germplasm for breeding
- concept of gene pools and wild crop relative

III. Conventional methods for crop improvement
- breeding for self vs cross pollinated
- recurrent selection
- backcross breeding

IV. Modern methods of crop improvement
- Molecular genetic breeding - Marker assisted breeding for important traits (Case study)
- Genome Wide Association Study (GWAS)
- Genomic selection
- Speed breeding

V. Application of genetic transformations in crop improvement

Content (Tutorial)

- **Addressing individual queries** on class concepts
- **Discussing research papers** on seminal work in the field exemplified by the following
  - Shull GH (1909) A pure-line method in corn breeding. Journal of Heredity 1:51-58.
  - Borlaug NE (1970) The Green Revolution: Peace and Humanity. https://repository.cimmyt.org/entities/publication/73b44ad5-1fc1-4188-a413-0e68ddab5f60
  - Schell J, Van Montagu M (1977) The Ti-plasmid of *Agrobacterium tumefaciens*, a natural vector for the introduction of nif genes in plants? Basic Life Sciences 9:159-79.
  - Tanksley SD, McCouch SR (1997) Seed banks and molecular maps: unlocking genetic potential from the wild. Science 277(5329):1063-6.
  - Ashikari M, Sakakibara H, Lin S, Yamamoto T, Takashi T, Nishimura A, Angeles ER, Qian Q, Kitano H, Matsuoka M (2005) Cytokinin oxidase regulates rice grain production. Science 309(5735):741-5.
  - Ravindran S (2012) Barbara McClintock and the discovery of jumping genes. Proc Natl Acad Sci U S A. 109(50):20198-9.
- **Discussing relevant video** content exemplified by
  - "Norman Borlaug & The Green Revolution" - A brief overview of Borlaug's work and its impact on global agriculture (https://www.youtube.com/watch?v=Lg9-HTtgFOk)
  - "Gene Editing and CRISPR in Agriculture" - A TED Talk by Jennifer Doudna (https://www.youtube.com/watch?v=TdBAHexVYzc)
  - "Marker-Assisted Selection in Plant Breeding" - An overview of MAS, including examples of successful applications in crop improvement

(https://www.youtube.com/watch?v=NdaUqGBHuD4 & https://www.youtube.com/watch?v=Vie33tMyX74)

- "Genetically Modified Crops and Their Impact" - Discussion on transgenic crop development, biosafety protocols, and societal implications (https://www.youtube.com/watch?v=jYjvJyEMHZ4 & https://www.youtube.com/watch?v=0OdQVB-akww)

- **Performing class exercises** such as
  - Simulating Marker-Assisted Selection (MAS) using real-world genetic data.
  - Designing a genetic map for drought tolerance using hypothetical QTL data.
  - Constructing a physical map for stress-responsive genes.
- **Analysing results of research papers** as quiz-based class discussions such as 'Identification of candidate genes for stress tolerance'
- **Discussion** on use of gene editing techniques in crop improvement; ethical considerations and biosafety protocols
- **Exploring digital resources** for understanding scope of experimental model systems such as
  - Mendel's seminar contributions (https://gregormendel200.org/gregor-mendel-2/his-life/)
  - Virtual Tour of IRRI - Exploring Rice Genetic Resources (https://www.irri.org)
  - Interactive Plant Breeding Platform (https://www.plantbreedingplatform.org)
  - Svalbard Global Seed Vault (https://www.croptrust.org/work/svalbard-global-seed-vault/)
- **Visiting different plant growth facilities** to give students a real time experience

Suggested Reading

1.	Principle of Crop improvement	Simmonds NW & Smart J	Blackwell Science
2.	Research papers for case studies		

SEMESTER 1 **2C-GEN-111** 2Y-PG

Statistical Analysis in Biology

Course Objective: *Much of genetic analysis is based on quantitative data and therefore statistical techniques are used extensively. Data analysis requires an individual to firstly choose an appropriate test among the gamut of tools available and then have the skill to apply it. Therefore in this hybrid mode of learning, students will be first equipped with conceptual understanding of the principles of using these statistical tools. This will be followed hands-on technical learning based upon the FOSSEE (Free/Libre and Open-Source Software for Education) project which promotes the use of FLOSS tools in academia and research [FOSSEE Project - National Mission on Education through Information and Communication Technology (ICT), Ministry of Education (MoE), Government of India}. Though most of the teaching will follow a hybrid mode, the course has been structured into separate theory and practical components to meet syllabus requirements.*

	Total	Theory	Practical	Tutorial
Credits	2	1	1	0
Hours	45	15	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	25	1
Practical	25	1

Unit	Unit Name	Hours
Theory		
I	Basic statistics	2
II	Tests of statistical significance	2
III	Regression and correlation	3
IV	Analysis of variance (ANOVA)	3
V	Introduction to R-package.	2
VI	Correlation and Multivariate Analysis	3
Practical		
I	Statistics using JASP	15
II	Statistics using R	15

Course Outcome: On completing 'Statistical Analysis in Biology' the students would have:

- Learnt which Statistical Methods to apply when given a biological question and dataset.
- Understood fundamental statistical concepts, experimental design, data visualization, significance testing, regression, and ANOVA.
- Gained experience in Computational and Multivariate Analysis and used R for data analysis, exploring correlations, PCA, and clustering techniques for genetic data interpretation.

Content (Theory)

I. Basic statistics

- Samples and populations
- experimental design,
- data analysis, graphs
- average
- coefficient distributions (chi-square, binomial, poisson and normal)

II. Tests of statistical significance

- t-test, z-test, F-test, U-test and others;

III. Regression and Correlation

IV. Analysis of Variance (ANOVA)

V. Introduction to R-package

VI. Correlation and Multivariate Analysis

- Pearson vs. Spearman correlation
- Principal Component Analysis (PCA) for high- dimensional genetic data
- Cluster analysis and classification techniques in genetics

Content (Practical)

Designed in a hybrid mode to blend theory, virtual learning with hands-on experience

I. Statistics using JASP

This topic includes biological data analysis using JASP software. The datasets/library for JASP is available on the Open Science Framework (OSF) as well as GitHub repository.

- Descriptive statistics and data visualization
- Exploring data integrity – Detection of outliers and Testing for assumptions (Normality and Homoscedasticity)
- Hypothesis Testing (T-test, binomial test, Multinomial test, Comparing two or more than groups)
- Correlation and Regression
- Non-parametric tests (Spearman's rank correlation and Kruskal-Wallis – Non-parametric ANOVA)

II. Statistics using R

The principal aim is to provide a step-by-step guide on the use of R statistical language to carry out statistical analysis and techniques widely used in life, chemical and physical sciences

- Descriptive Statistics and Tabulation
- Introduction to Graphical Analysis
- Hypothesis Testing
- Creating an interactive R Notebook/R Markdown document with code chunks and embedded output

Suggested Reading

1.	Biostatistics	Danial WW	Wiley
2.	Statistical Methods in Biology	Bailey NTJ	Cambridge Univ. Press

COURSE DETAILS

ALL PAPERS OFFERED IN SEMESTER 2 OF THE 2Y-PG

SEMESTER 2 **DSC-GEN-201** 2Y-PG

Regulation of Gene Expression

***Course Objective**: This course explores gene regulation across prokaryotic and eukaryotic systems, from basic mechanisms in bacteria to complex networks in multicellular organisms. It examines how gene expression is controlled at various levels, linking theory with real-world examples from development, disease, and therapy. Units I and II lay the foundation by connecting bacterial and eukaryotic regulation, while Units III and IV focus on epigenetic control in development and disease. Unit V integrates these concepts, applying regulatory network insights to human diseases for a comprehensive understanding of gene regulation.*

	Total	Theory	Practical	Tutorial
Credits	4	3	1	0
Hours	75	45	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	75	3
Practical	25	6

Unit	Unit Name	Hours
Theory		
I	Concepts and Strategies in Gene Regulation: *lessons from bacteria and yeast*	10
II	Gene Regulation in Eukaryotes: *Complexity in Multicellular Systems*	10
III	Introduction to Epigenetics: *Beyond the Genetic Code*	10
IV	Epigenetic Events in Development and Disease: *Biological Consequences*	10
V	Genes Gone Rogue: *Disruption of Regulatory Networks in Disease Gene Regulatory*	5
Practical		
I	Analysing gene regulation in *E. coli* using lac operon as a model	8
II	Analysing gene expression at the organismal level	8
III	Studying Gene-environment interaction	14

Course Outcome: On completing 'Regulation of Gene Expression' the students would have:

- Gained a comprehensive understanding of gene regulation mechanisms wherein gene regulation at transcriptional, post-transcriptional, translational, and post-translational levels in prokaryotes and eukaryotes would be explored, integrating theory with experiments.
- Analysed the role of epigenetics in development and disease with details on epigenetic mechanisms like DNA methylation, histone modifications, and chromatin remodeling, linking them to gene expression and disease.
- Develop the ability to investigate and analyse mechanisms of gene regulation and expression at molecular, cellular, and organismal levels, including gene-environment interactions and epigenetic modifications.

Content (Theory)

I. **Concepts and Strategies in Gene Regulation:** ***lessons from bacteria and yeast***

- ***Recap –*** The process of information flow
- ***Regulatory Mechanisms Across Levels:***
    - Overview of transcriptional, post-transcriptional, translational, and post-translational regulation.
    - Experimental strategies for analysing gene regulation across different levels.
    - Positive and negative regulators: Building inducible and repressible systems.
- ***Lessons from Prokaryotic Systems:***
    - Jacob and Monod's Seminal Model
    - Comparative analysis of regulation of lactose, tryptophan, and arabinose operons
    - λ Phage: Genetic switch governing lysis and lysogeny.
    - Global regulatory systems: e.g. Role of sigma factors in bacterial gene regulation.
- ***Regulatory Insights from Yeast:***
    - The GAL1 system in *Saccharomyces cerevisiae*: Eukaryotic parallels to bacterial models.
- ***Connecting Prokaryotic and Eukaryotic Concepts:***
    - Drawing parallels between prokaryotic regulatory strategies and eukaryotic gene control.

II. Gene Regulation in Eukaryotes: ***Complexity in Multicellular Systems***

- **Signal Perception**:
    - Recap of cell signalling pathways
    - Parallels in bacterial systems
- **Transcriptional, Post-Transcriptional and Translational Regulation**
    - Regulation at constitutive, inducible, and tissue-specific promoters
    - Regulation by alternative splicing, RNA editing, mRNA stability
    - Translational regulation: control at initiation, codon usage, and efficiency.
    - Post-translational modifications and their role in fine-tuning gene expression.
    - Control by small RNAs, including miRNAs and siRNAs, linking to epigenetic regulation.
- **Connecting Prokaryotic and Eukaryotic Concepts**
    - Drawing parallels between prokaryotic regulatory strategies and eukaryotic gene control.

III. Introduction to Epigenetics: ***Beyond the Genetic Code***

- **Epigenetic Mechanisms and Pathways**
    - Overview of epigenetic regulation: Concepts and biological significance.
    - Chemical modifications: DNA methylation and histone modification in chromatin structure & tools for their detection
- **Chromatin Remodelling and DNA-Binding Proteins**
    - Role of Polycomb and Trithorax group proteins
    - Chromatin remodeling – Histone variants and Families of remodelers

III. Epigenetic Events in Development and Disease: ***Biological Consequences***

- **Epigenetic Events Across Organisms**
    - Genomic imprinting, X chromosome inactivation and transgenerational inheritance in mammals.
    - Vernalization in plants: Epigenetic response to environmental cues.

- miRNAs in cell fate determination in *Caenorhabditis elegans*.
- Heterochromatin and mating type switching in *Saccharomyces cerevisiae*.
- Cellular memory and homeotic transformations in development across species.

- **Epigenetics in Stem Cell Reprogramming and Disease Biology**
  - Cellular reprogramming and their potential in regenerative medicine.
  - Application of epigenetic techniques in various biological systems with a focus on disease models and developmental biology.

IV. Genes Gone Rogue: Disruption of Regulatory Networks in Disease

- Acquiring and analysing gene regulatory networks using examples from cancer, neurodegenerative diseases, and immune disorders.
- Epigenetic imprinting defects in human diseases.
- Targeting gene regulation in disease treatment: Epigenetic drugs, RNA therapies, and CRISPR-based interventions.

Content (Practical)

V. Analysing gene regulation in *E. coli* using lac operon as a model

- Induction kinetics: comparative study between IPTG and lactose
- Expression of lac operon in the presence of different carbon sources
- Expression of lac operon in mutants generated in semester I (DSC-GEN-103)

VI. From basics to application (using any one example)

- Using *lacZ* gene from *E. coli* to study cell type-specific promoter activity in *Dictyostelium* -would include making transformants, histochemical staining during development, comparing expression in wild type and mutants
- The UAS-GAL4 system from yeast to direct tissue specific expression in *Drosophila*

VII. Studying Gene-environment interaction

- Evaluating change in transcript expression of a gene in cancer cell-line under chemical/hypoxic/starvation (mimicking tumour microenvironment) stress using RT-PCR
- Investigating whether observed changes in gene expression are due to alterations in promoter methylation using methyl-specific PCR

Suggested Reading

1.	Genes and Signals	Mark Ptashne& Alexander Gann	CSHL Press
2.	A Genetic Switch	Mark Ptashne	CSHL Press
3.	Gene Regulation	David S.Latchmann	Chapman & Hall
4.	The *lac* operon	Benno Muller-Hill	Walter de Gruyter
5.	Genes	Benjamin Lewin	Prentice Hall
6.	Molecular Cell Biology	Lodish H *et al.*	W.H Freeman
7.	Molecular Biology of the Cell	Alberts B *et al.*	Garland Science
8.	Epigenetics	David AllisC	CSHL Press
9.	Classic and seminal papers in gene regulation		
10.	Research and review papers in epigenetics		

SEMESTER 2 **DSC-GEN-202** 2Y-PG

Recombinant DNA Technology

Course Objective: *Recombinant DNA technology is a set of molecular techniques for localization, isolation, alteration and study of DNA segments or genes. Commonly known as genetic engineering it encompasses various ways to analyze, alter and recombine virtually any DNA sequences. Parting away from the classical gene-phenotype relationship, this technology provides information through direct reading of the nucleotide and/or protein sequences. This paper provides the details of various approaches, techniques and tools used as well as their application in the generation of commercial products of myriad usage (biotechnology).*

	Total	Theory	Practical	Tutorial
Credits	4	3	1	0
Hours	75	45	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	75	3
Practical	25	3

Unit	Unit Name	Hours
Theory		
I	Methods of DNA, RNA and protein analysis	6
II	Gene cloning and identification	13
III	Expression Analysis	10
IV	Protein expression, engineering and interactions	13
V	Applications of recombinant DNA technology in biology and medicine	3
Practical		
I	Handling small volumes	4
II	Agarose gel electrophoresis	7
III	Quantitating DNA	4
IV	Restriction digestion and ligation	15

Course Outcome: On completing '**Recombinant DNA Technology'**, the students would have:

- Learned key methods for DNA, RNA, and protein analysis, including electrophoresis, blotting techniques, gene cloning, and genome sequencing
- Explored expression analysis techniques such as PCR, transcriptome analysis, protein expression systems, and **methods for studying protein interactions**.
- Examined the applications of recombinant DNA technology in biology and medicine, including gene editing tools like CRISPR, ZFN, and TALENs.
- Been equipped with essential laboratory skills required to successfully carry out the subsequent project module.

Content (Theory)

I. Methods of DNA, RNA and protein analysis:

- Electrophoretic techniques: agarose and polyacrylamide gel electrophoresis, native, SDS, and 2-D PAGE
- Blotting techniques – Southern, northern, and western blots; Preparation of probes; RFLP analysis, DNA fingerprinting and its application.

II. Gene cloning and identification

- Basics of cloning- Restriction and DNA modifying enzymes; Isolation and purification of nucleic acids; cloning methods; Cloning vectors – plasmids, phages, lambda vectors, phagemids, cosmids, fosmids, PAC, BAC and YAC; Selection and screening of clones.
- Construction of DNA libraries- Genomic and cDNA libraries; Screening of genomic and expression libraries.
- Gene identification- Subtractive hybridization, chromosome walking and jumping.
- Genome sequencing- DNA sequencing by Maxam and Gilbert method, Sanger's method, whole genome shotgun sequencing, next generation sequencing; Genome annotation: an overview

III. Expression Analysis

- Polymerase Chain Reaction (PCR)- Concept of PCR, Primer designing, various kinds of PCR- Nested, Multiplex, Stem-loop and inverse PCR, , Real-Time PCR, Digital/Droplets PCR, Ligation Chain Reaction; Applications of PCR; EST analysis, Promoter analysis; Mapping transcriptional start sites
- Analysis of gene expression: Northern blotting, Reverse transcription(RT) PCR, quantitative RT-PCR
- Transcriptome analysis – cDNA- and oligo arrays; Serial Analysis of Gene Expression (SAGE).

IV. Protein expression, engineering and interactions:

- Expression of recombinant proteins: Expression and tagging of recombinant proteins in *E. coli*, Other expression systems
- Protein engineering- Insertion and deletion mutagenesis, site-directed mutagenesis
- Proteome analysis: MALDI, protein arrays and their applications
- Analysis of protein-DNA and protein-protein interactions, Reverse Two-Hybrid Systems, gel retardation assay, Dnase-I footprinting, Yeast two and three-hybrids assay
- ChIP on chip assay
- Split and reverse hybrids
- Co-immunoprecipitations; Phage display

V. Applications of recombinant DNA technology in biology

- Gene editing technologies: Cre-Lox, ZFN, TALENs, CRISPR/Cas9, HDR.

Content (Practical)

A primer to recombinant DNA techniques:

I. **Handling small volumes:**

- Handling microvolumes: use of micropipettors and determining their accuracy by the gravimetric method.
- Preparation of dilution of given DNA (lambda DNA) sample and measure the absorbance at 260 nm to check the accuracy of dilution.

II. **Agarose gel electrophoresis:**

- Making gels of different percentages (0.8, 1.0, and 1.5) and resolving fragments of different sizes (e.g. 1 Kb and 100 bp DNA ladders); plotting migration distance versus size to understand the concept of differential migration on agarose gel.

III. **Quantitating DNA:**

- Absorbance of microvolumes; visual inspection on agarose gel using a dilution series of DNA samples of known concentration (e.g. lambda DNA).

IV. **Restriction digestion and ligation:**

- Digesting a commercially available DNA sample (e.g. lambda DNA) with different enzymes, varying incubation time and enzyme units.
- Setting up ligation of digested lambda DNA and observing ligation by gel electrophoresis.

Suggested Reading

1.	Gene Cloning and DNA Analysis: An Introduction	Brown TA	Blackwell Publications
2.	Gene Cloning and Manipulation	Howe C	CambridgeUniversity Press
3.	Principles of Gene Manipulation and Genomics	Primrose SB&Twyman RM	Blackwell Publications
4.	Principles of Gene Manipulation	Primrose SB Twyman RM & Old RW	WileyBlackwell
5.	Molecular Cloning: A Laboratory Manual (3- Volume Set)	Sambrook J *et al.*	CSHL Press
6.	Calculations for Molecular Biology and Biotechnology	Stephenson FH	Academic Press

SEMESTER 1 **DSC-GEN-203** 2Y-PG

Experiential learning in Genetics – II

***Course Objective**: This project-based module aims to give students a complete and connected understanding of how to clone and express a gene of interest (GOI) in E. coli. Instead of learning individual techniques in isolation, students will experience how these methods come together in a real research-like setting. Building on their earlier priming on working with DNA, students will now apply and deepen their understanding through hands-on work. As they move through the project, they will not only plan and execute experiments but also learn and refine key recombinant DNA techniques as part of the process. The emphasis is on thinking through the workflow, dealing with experimental setbacks, and finding ways to troubleshoot and improve. The module encourages curiosity, collaboration, and creative problem-solving—helping students grow into confident, independent learners in the lab.*

Credits	Theory	Practical	Tutorial
4	0	4	0
Hours	0	120	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Practical	100	6

Unit	Unit Name	Hours
Practical		
I	*From Gene to Protein – Cloning and expression in E. coli*	120

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

- Design and execute a recombinant DNA workflow for cloning and expressing a gene of interest in *E. coli*
- Apply and refine key recombinant DNA techniques as part of an integrated project rather than isolated protocols
- Analyse and troubleshoot experimental results, learning from failures and modifying strategies accordingly
- Demonstrate scientific thinking and collaborative problem-solving in a research-like laboratory setting

Content (Practical)

I. *From Gene to Protein – Cloning and expression in E. coli*

Objective: To clone a gene of interest (GOI) into an *E. coli* expression system, express a His-tagged recombinant protein, and analyse it using SDS-PAGE and Western blotting. The envisaged work flow is as follows:

Note:
The following workflow exemplifies the processes that are envisaged to be covered in a seamless fashion. Variations in detail and methodology may occur based on specific project goals, organism of origin, available resources, or experimental choices made by students and instructors. This is a general guide to the typical steps involved.

- **Select a Gene of Interest (GOI)**
  Identify a biologically relevant, preferably intron-less gene from an organism such as *Drosophila*, *E. coli*, or human. Retrieve the sequence from a public database and define the coding region to be cloned.
- **Design the cloning strategy**
  Choose an appropriate expression vector (e.g., pET28a, pGEX). Select restriction enzyme sites preferably for directional cloning, plan for placement of tags (e.g., His-tag), and include translational signals like Shine-Dalgarno or Kozak sequences if necessary.
- **Isolation of genomic DNA**
  Analyse the yield and quality by gel electrophoresis, absorbance and ease with which it is digested.
- **Primer design & PCR amplification**
  Design primers with flanking restriction sites and tag sequences if needed. Perform PCR with optimized conditions (annealing temperature, Mg^{2+} concentration, extension time), and purify the amplified product
- **Prepare insert and vector and create recombinants**
  Digest of the PCR product (is needed) and vector with selected enzymes, purify by gel elution, dephosphorylation and ligation, optimizing the insert-to-vector ratio and reaction conditions.
- **Transformation into competent *E. coli***
  Make competent *E. coli* cells for transformation, test transformation efficiency. Transform recombinant molecule and select for recombinants using alpha-complementation.
- **Screen for positive clones**
  Screen colonies using colony PCR or restriction digestion of plasmid mini-preps to confirm the presence and correct orientation (is applicable) of the insert. Sequence to check correctness of the insert. While sequencing happens, students may proceed for the next steps using available recombinant clones.
- **Protein expression and analysis by SDS PAGE.**

Optimize induction by varying concentrations of IPTG, time and temperature of induction to improve yield and solubility. Harvest and lyse induced cells using lysozyme and sonication. Run cell lysates on SDS-PAGE and stain with Coomassie Blue to assess protein expression and approximate size.

- **Western Blotting**
  Confirm the correctness of the expressed protein using antibodies against His-tag.
- **Purification of the protein (optional)**
  Purify the protein by affinity chromatography

SEMESTER 2 **DSE-GEN-204** 2Y-PG

Developmental Biology

Course Objective: *This course offers a comprehensive exploration of the molecular, cellular, and evolutionary mechanisms that drive the transformation of a single cell into a fully developed organism. By drawing on insights from diverse model organisms—including animals, plants, and unicellular systems—students will delve into fundamental concepts such as cell fate determination, morphogenesis, organogenesis, and regeneration. The course is inspired by Scott F. Gilbert's Developmental Biology, blending classical concepts with modern research developments.*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	75	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	75	3
Practical	25	3

Unit	Unit Name	Hours
Theory		
I	Core Concepts of Developmental Biology	8
II	Gametogenesis and Fertilization	11
III	Early Development, axis formation, organogenesis in animals	10
IV	Pattern formation in plants	13
V	Evo - Devo	3
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing 'Development Biology,' students would have:

- Developed a comprehensive insight into the basics of developmental biology with molecular, cellular, and evolutionary mechanisms guiding the transformation of a single cell into a fully developed organism across various model systems, would be gained.
- Analysed key developmental processes in animals and plants by examining cell fate determination, morphogenesis, organogenesis, and regeneration, comparing unique developmental strategies in both plant and animal systems.
- Evaluated evolutionary and genetic influences on development by exploring the role of gene regulation, environmental interactions, and evolutionary principles in shaping developmental patterns and organismal diversity.

Contents (Theory)

I. Core Concepts of Developmental Biology

- The cycle of life – life cycle of animal and flowering plants
- Overview of animal and plant development
- Importance of model organisms in developmental research
- Basic approaches to observe development
- Experimental approaches – 'Find it, Loose it, Move it'
- Basic concepts on how cells attain fate - Specification, induction, competence, determination, and differentiation
- Morphogen gradients and their role in pattern formation
- Cell-to-cell communication
- Gene regulatory networks and developmental decision-making
- Comparison between plant and animal developmental patterns
- Achieving multicellularity : division versus aggregation (*Dictyostelium*)
- Stem cells

II. Gametogenesis and Fertilization

- Gametogenesis in plants and animals
- External fertilization in sea urchin
- Internal fertilization in mammals
- Fertilization in angiosperm plants

III. Early Development, axis formation, organogenesis in animals

- A comparative analysis of early developmental processes and axis formation across different model organisms, including *C. elegans*, Drosophila, sea urchins, amphibians, birds, and mammals highlighting
  - Initiation of development and cleavage – exploring distinct patterns and mechanisms
  - Gastrulation and its outcomes - from classical experimental studies to modern molecular insights, highlighting the formation of germ layers and their developmental fates.
  - Axis Specification (Anterior-Posterior and Dorsal-Ventral) – a detailed analysis genetic and molecular mechanisms with emphasis on identifying key genes that regulate axis formation and determine cell fates.
- Formation of vulva in *C. elegans*
- Formation of tetrapod limb
- Regeneration

IV. Pattern formation in plants

- Salient features of plant development, comparison between plant and animal development pattern
- Understanding plant development through examples –
  - Polarity determination during plant development
  - Regulation of transition to flowering,
  - The ABCDE model of flower development in Arabidopsis and its variations.

V. Evo - Devo

- Reconditions for evolution

- Mechanisms of evolutionary change: heterotropy, heterochrony, heterometry and heterotypy
- Developmental constraints on evolution
- Plasticity-first evolution
- Selectable epigenetic variations
- Evolution and developmental symbiosis

Contents (Tutorial)

- Addressing **individual queries** on class concepts
- Screen different videos on developmental biology which will help initiate discussions and help students attain a better perspective of the subject. Some examples are
    - **Developmental Biology Tutorials by Barresi Lab**
      A series of video tutorials covering key concepts in developmental biology.
      https://www.science.smith.edu/barresilab/developmental-biology-tutorials/
    - iBIOLOGY videos e.g.
        - Collaborating to find developmental genes
        - Control of embryonic axis formation in Drosophila involving Gurken
        - Cytoenemes: signalling at a distance
    - Videos from the Company of Biologists e.g.
      The Fascinating World of Developmental Biology
      https://www.youtube.com/watch?v=avrmls3vPUQ
    - Videos showing experimental strategies to study developmental biology
- Classroom demonstration of observing chick development- window preparation
- Visit to institutes like IGIB and NII to experience the use of model systems of developmental like the zebra fish and C. elegans

Suggested Reading

1.	Developmental Biology	Scott F. Gilbert	Sinauer Associates, Inc.
2.	Principles of Development	Lewis Wolpert.	Oxford University Press

SEMESTER 2 **DSE-GEN-205** 2Y-PG

Immunology & Immunogenetics

Course Objective: *The course provides a comprehensive overview of basic concepts of immune system, mechanism of T and B cell mediated immunity and the humoral response including the complement system. Generation of peripheral and central tolerance and topics of clinical relevance, such as autoimmunity, tumour immunology, congenital and acquired immunodeficiencies, transplantation immunology, and immunotherapy are covered. All the topics are studied through lectures and an in-depth review of selected articles.*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Discoveries and overview of the immune system	5
II	Innate Immune response	6
III	Adaptive immune response	4
IV	Organization and diversity of immunoglobulin genes	8
V	Development and maturation of T and B cells	8
VI	The adaptive immune response	8
VII	Immune system in health and disease	6
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing 'Immunology & Immunogenetics', students would have

- Acquired an overview of types of immunity including the historical development of immunology, immune organs, and cell differentiation. Concepts of pattern recognition receptors, the complement system, inflammation, and key cellular responses like phagocytosis and neutrophil activity would be clear to them
- Covered adaptive immunity and antigen recognition particularly humoral and cell-mediated immunity, cytokines, antigen presentation by MHC molecules, and antigen recognition by BCRs, TCRs, and Fc receptors.
- Understood immune development and disorders including immunoglobulin gene organization, VDJ recombination, class switching, T and B cell development, and tolerance. The course concludes with immune-related diseases, including autoimmunity, hypersensitivity, and immunodeficiencies

Contents (Theory)

I. **Discoveries and overview of the immune system**
   - Historical development and seminal discoveries of immunology
   - Immune cells – haematopoiesis, fate determination of myeloid and lymphoid progenitor cells
   - Organs of the immune system

II. **Innate Immune response**
   - comparative immunology (lower order to vertebrates)
   - Pattern recognition– four family of receptors and their pathways
   - **c**omplement pathway (Classical, Alternate and Lectin)
   - Inflammation
   - Response to a finger prick - Analyzing tumor, rubor, calor and dolor
   - Phagocytosis
   - Neutrophil migration and neutrophil extracellular traps

III. **Adaptive immune response**
   - Humoral and cell mediated immune response
   - Cytokines and chemokines
   - Antigen recognition and presentation
   - Recognition by different cell-types
   - Major Histocompatibility complex (MHC) genes and their organization
   - MHC restricted cell types and T-cell receptors
   - Antigen presentation by MHC class I and class II
   - Receptors engaged in antigen recognition – FcR, BCR and TCR
   - Antigen antibody interaction

IV. **Organization and diversity of immunoglobulin genes**
   - Antibody structure, types and domains
   - Generating diversity through recombination, molecular mechanisms of the VDJ recombination
   - The mechanisms and process of class switch recombination
   - Stepping up the immune response – Somatic Hypermutation and Affinity Maturation

V. **Development and maturation of T and B cells**
   - Molecular and cellular pathway of T cell development
   - T cell maturation, types of T cells and their functions
   - Central and peripheral tolerance
   - Molecular and cellular pathway of B cell development, and maturation
   - Activation of B and T cells

VI. **Immune system in health and disease**
   - Immunological Tolerance and Autoimmune diseases
   - Allergy and hypersensitivity
     Transplantation immunology
   - Immunodeficiencies

Content (Tutorial):

- **Addressing individual queries** on class concepts
- **Discussing research papers** on seminal work in the field exemplified by the following

    - The concept of variolation across ages - Boylston A. The origins of inoculation. J R Soc Med. 2012 doi: 10.1258/jrsm.2012.12k044.
    - Humoral and cell-mediated immunity go hand-in-hand. Kaufmann, S. Immunology's foundation: the 100-year anniversary of the Nobel Prize to Paul Ehrlich and Elie Metchnikoff. (2008). https://doi.org/10.1038/ni0708-705
    - Metchnikoff's stellar contribution.Jean-Marc Cavaillon & Sandra Legout. Centenary of the death of Elie Metchnikoff: a visionary and an outstanding team leader (2016) (https://www.sciencedirect.com/science/article/pii/S1286457916300697)
- **Discussing relevant video and reading content** exemplified by -
    - The controversies around Pastuer's work and records. Smith KA. Louis Pasteur, the father of immunology? Front Immunol. 2012 Apr 10;3:68. doi: 10.3389/fimmu.2012.00068.
    - Susumu Tonegawa – Nobel Laureate 1987 for his discovery of VDJ recombination (https://youtu.be/-rdcXmb8-jo?si=kMJo0419w3C_PWMr)
- **Analysing results of research papers** as quiz-based class discussions such as -
    - Learning from the groundbreaking work on antibody diversity. Hozumi N, Tonegawa S. Evidence for somatic rearrangement of immunoglobulin genes coding for variable and constant regions. (1976) (doi:10.1073/pnas.73.10.3628)
- **Discussions** on
    - Fetal-maternal health
    - Controversies around Louis Pasteur's work – a question on conduct & ethics
    - Gut microbiome & Indian knowledge system
    - Immunity while growing up and aging
- **Integrative learning** through examples such as
    - Possible outcomes when a bee stings and a thorn pricks?
- **Exploring digital resources** for understanding scope of immunological techniques such as:
    - Flow cytometry and Cell sorting (https://youtu.be/W1BFeiDwqnk?si=3Gw4ypX3Xo17IiZg)

Suggested Readings

1.	Kuby Immunology	Kindt TJ, Goldsby RA, Osborne BA, Kuby J	W H Freeman & Co
2.	Immunobiology: The immune system in health and disease	JanewayCA,Travers, P,Walport M, Shlomchik MJ	Garland Science Publishing
3.	Roitt's Essential Immunology	Delves PJ, Martin SJ, Burton DR, Roitt IM	Blackwell Publishing/Oxford Univ. Press

SEMESTER 2 **DSE-GEN-206** 2Y-PG

Mitochondrial Biology & Connection to Cell Physiology

Course Objective: *In the last decade, Mitochondria have been recognized to be highly dynamic. Most undergraduate courses lack any relevant critical examination of various aspects of mitochondrial cell biology, which the course aims to do. Here in, we will deal with the mitochondrial genetic material organization in eukaryotes, mode of replication and cytoplasmic inheritance, aspects of process linked to connection with cellular metabolism, and energy production. We will also examine the signals and machinery regulating mitochondrial copy numbers and partitioning during cell division. Various unique features of mitochondrial gene expression will be delved into, in addition to diseases caused by disrupted mitochondrial activity*

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Mitochondrial genome organization	5
II	Mitochondrial Physiology	10
III	Mitochondrial dynamics	10
IV	Mitochondrial gene expression	10
V	Mitochondrial genetics and molecular medicine	10
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing, 'Mitochondrial Biology & Connection to Cell Physiology' students would have:

- Understood the organization and function of the mitochondrial genome by exploring the dual nature of the mitochondrial proteome, its evolutionary links to bacteria, mechanisms of protein import and sorting, and the principles of non-Mendelian inheritance.
- Analysed mitochondrial physiology and dynamics by examining mitochondrial metabolic pathways, retrograde signalling, copy number control via fusion and fission, and quality control mechanisms, including mitophagy and transport to daughter cells.
- Evaluated the role of mitochondrial gene expression and genetics in disease and the impact of mutations in mitochondrial and nuclear genomes on human diseases.

Contents (Theory)

I. **Mitochondrial genome organization**
- Dual nature of mitochondrial proteome
- Evolutionary links to bacteria
- Mitochondrial protein import and sorting mechanism
- Non-mendelian transmission of mitochondrial genetic material

II. **Mitochondrial Physiology**
- Metabolic pathways touching mitochondria
- Mitochondrial output control by nuclear genome
- Mitochondrial retrograde signaling
- links to cellular life span

III. **Mitochondrial dynamics**
- Mitochondrial copy number control via fusion and fission
- transport of mitochondria to daughter cells
- mitochondrial quality control
- mitophagy

IV. **Mitochondrial gene expression**
- unique features of transcription
- ribosome structure, and protein translation in mitochondria
- Transcriptional and translational control by nutrition- Amino acid starvation and TOR signaling, glucose repression and de-repression.

V. **Mitochondrial genetics and molecular medicine**
- Disease examples due to mutation in nuclear and mitochondrial genome.

Content (Tutorial)

- **Addressing individual queries** on class concepts
- **Discussing research papers on seminal work** :
  - on discovering mitochondrial fusion and fission machinery. A few examples are here.
    - Fusion -Sesaki and Jenson (2001) https://doi.org/10.1083/jcb.152.6.1123
    - Morphology- Otsuga et al (1998)https://doi.org/10.1083/jcb.143.2.333
    - Fission-Mozdy, McCaffrey and Shaw (2000) https://doi.org/10.1083/jcb.151.2.367
  - on seminal work on discovering protein synthesis by ribosomes attached to the mitochondria. A few examples are here.
    - Biogenesis-Marc et al (2002) https://doi.org/10.1093/embo-reports/kvf025& Garcia et al (2010)https://doi.org/10.1038/embor.2010.17
  - on seminal work related to understanding the alternate translation system within the mitochondria with a special focus on the ribosome structure and translation initiation
    - Fox TD (2012) https://doi.org/10.1534/genetics.112.141267

- The following **videos** will be used to discuss the essential functioning of the mitochondria for a healthy cell.
  - https://www.ibiology.org/cell-biology/mitochondria-metabolism/
  - https://www.ibiology.org/cell-biology/mitochondrial-pyruvate-carrier/
  - https://www.ibiology.org/cell-biology/mitochondria/
  - https://www.ibiology.org/cell-biology/mitochondria/

Suggested Reading

1.	Classical and current Research Papers	Shared by the teacher	
2	Mitochondria	Douglas C. Wallace and Richard J. Youle	CSHL Press
3	Mitochondrial Biology: New Perspectives	Derek J. Chadwick (Editor), Jamie A. Goode (Editor)	By Novartis Foundation, John Wiley & Sons Inc
4	The Human Mitochondrial Genome: From Basic Biology to Disease	Giuseppe Gasparre and Anna Maria Porcelli	
5	Mitochondria and the Future of Medicine	Lee Know	Chelsea Green Publishing Co

SEMESTER 2 **GE-GEN-210** 2Y-PG

Genetics in Everyday Life: from DNA to Society

Course Objective:

This General Elective course introduces the basic principles of genetics, focusing on their relevance to everyday life, health, technology, and society, along with the ethical questions raised by emerging genetic technologies. It offers a broad understanding of how genetic concepts connect to real-world challenges, without getting into technical complexities. Designed for students from diverse academic backgrounds, the course uses real-world case studies, interactive debates, and accessible readings to help students explore key ideas and their societal impact, encouraging critical thinking and ethical reflections.

	Total	Theory	Practical	Tutorial
Credits	4	3	0	1
Hours	60	45	0	15

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	100	3

Unit	Unit Name	Hours
Theory		
I	Introduction to Genetics	12
II	Genetics in Health and Medicine	12
III	Genetics in Society and Environment	11
IV	Ethical, Legal, and Social Issues (ELSI) in Genetics	11
Tutorial		
	Various modalities as given below	15

Course Outcome: On completing 'Genetics in Everyday Life: From DNA to Society' the students would have :

- Understood genetic principles in everyday life by gaining a foundational understanding of genes, inheritance, and genetic diversity, exploring how genetics shaped traits, health, and interactions with the environment.
- Explored the role of genetics in health, society, and technology by analyzing real-world applications of genetics in medicine, agriculture, biodiversity, and forensic science, assessing the benefits and risks of genetic advancements like CRISPR, genetic testing, and GMOs
- Critically assessed ethical and social implications by engaging in discussions on ethical dilemmas, genetic privacy, and the societal impact of genetic technologies, developing an informed perspective on how genetics influenced public policies and everyday decisions.

Content (Theory)

I. **Introduction to Genetics**
   - Genes, genomes, and chromosomes
   - The genetic basis of diversity: Mutations and variations
   - Interaction of genes and environment to shape phenotypes
   - How traits are passed down

II. **Genetics in Health and Medicine**
   - Genetics and human diseases
   - Personalized medicine: How your DNA can influence drug response
   - Genetic testing: Benefits, risks, and accessibility
   - Gene therapy and CRISPR: Editing genes for better health

III. **Genetics in Society and Environment**
   - Genetically Modified Organisms (GMOs) and their impact on agriculture
   - Genetics and biodiversity: Conservation and endangered species
   - Forensic genetics: DNA fingerprinting in crime and identity verification

IV. **Ethical, Legal, and Social Issues (ELSI) in Genetics**
   - Ethical dilemmas: Designer babies, cloning, and eugenics
   - Genetic privacy: Who owns your genetic information?
   - Public perception of genetics: Misinformation and media portrayal

Content (Tutorial)

Case Studies for Discussion and Analysis – indicative examples

To enhance understanding and foster critical thinking, the course will incorporate real-world case studies across various units. These examples highlight the practical relevance of genetic concepts and their ethical, societal, and scientific implications.

- **Genetics in Health and Medicine**

  -The Angelina Jolie Case: BRCA1/BRCA2 Genetic Testing

  An exploration of hereditary breast and ovarian cancer risk assessment, genetic testing, and its implications for preventive healthcare.

  Sickle Cell Anemia and Malaria Resistance

  A case demonstrating how a single genetic mutation can confer disease resistance while also causing hereditary disorders, illustrating the complexity of natural selection at the genetic level

- **Genetics in Society and Environment**
  - *Transgenic Mustard: The Indian story:* Focusing on the science and the socio-political controversies surrounding genetically modified organisms (GMOs).
  - *DNA Fingerprinting and The Innocence Project:* An examination of forensic genetics' role in exonerating wrongfully convicted individuals, highlighting the power and ethical considerations of DNA evidence in the legal system.

- **Ethical, Legal, and Social Issues (ELSI) in Genetics**
  - *CRISPR Gene Editing: The Case of He Jiankui* - A critical analysis of the first reported gene-edited human embryos, exploring the ethical violations, global responses, and potential consequences of germline editing.
  - *Eugenics: A Historical Misuse of Genetics*- An investigation into the dark history of eugenics, focusing on policies in Nazi Germany and forced sterilizations in the United States, while reflecting on the importance of ethical boundaries in modern genetic research.

    These case studies will be supported by group discussions, interactive debates, and reflective assignments to help students connect theoretical knowledge with real- world applications and ethical dilemmas.

- **Discussion on Books (Popular Science and Introductory Texts) – indicative examples**

  Students can be encouraged to read any of the popular science books for discussion
  - Siddhartha Mukherjee – *The Gene: An Intimate History*
    A comprehensive history of genetics, tracing the journey from Mendel's early experiments to modern advancements like CRISPR.
  - Jennifer Doudna & Samuel Sternberg – *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*
    An insightful look into CRISPR gene-editing technology, co-authored by one of its pioneers, along with a discussion on its ethical implications.
  - Richard Dawkins – *The Selfish Gene*
    A foundational book explaining gene-centric evolution and natural selection, written in an engaging and accessible style.
  - Matt Ridley – *Genome: The Autobiography of a Species in 23 Chapters*
    A chapter-by-chapter exploration of the human genome, providing a deep yet accessible understanding of how our genes shape us.
  - Mark Lynas – *Seeds of Science: Why We Got It So Wrong on GMOs*
    A critical examination of the controversies surrounding genetically modified organisms (GMOs), written by an environmentalist who re-evaluated his stance based on scientific evidence.

SEMESTER 2 **2C-GEN-211** 2Y-PG

Microscopy and Imaging

***Course Objective**: Microscopy and imaging are technical expertise areas, aligning perfectly with the NEP's emphasis on skill-based learning. By training students to operate imaging tools and analyse biological data, it equips them with practical, research-ready skills essential for careers in modern biology, biotechnology, and healthcare. Hands-on technical learning cannot be built without a strong theoretical understanding. This hybrid course thus blends theory with hands-on training to provide insights into different types of microscopy and related techniques. Students will explore the principles behind various imaging techniques while directly engaging with instruments to connect the principles with their usage. The aim is to build both knowledge and practical skills for using microscopy in biological research. Though most of the teaching will follow a hybrid mode, the course has been structured into separate theory and practical components to meet syllabus requirements.*

	Total	Theory	Practical	Tutorial
Credits	2	1	1	0
Hours	45	15	30	0

Proposed Evaluation		
Exam	**Total Marks**	**Hours**
Theory	25	1
Practical	25	1

Unit	Unit Name	Hours
Theory		
I	Microscopy: Principles and application	3
II	Basic knowledge of principles and applications of the different microscopy types	7
III	Microscopy-based techniques and applications	5
Practical		
I	Microscopy: Principles and application	5
II	Basic knowledge of principles and applications of the different microscopy types	15
III	Microscopy-based techniques and applications	10

Course Outcome: On completing 'Microscopy and Imaging', the students would have:

- Understood the theoretical principles of various microscopy techniques including light, fluorescence, confocal, electron, and advanced imaging methods, and their applications in biological research.
- Acquired hands-on skills in operating different types of microscopes and imaging systems, along with basic competencies in image acquisition, processing, and analysis.

Content (Theory)

I. **Microscopy: Principles and applications**
   - Basic properties of light, light spectrum, image formation, fluorescence, and phosphorescence
   - Resolution, numerical aperture, aberrations, and corrective measures
   - Components in modern microscopes and types of objective lenses

II. **Basic knowledge of principles and applications of the different microscopy types**
   - Bright-field Microscopy, Dark-field Microscopy, Phase-contrast Microscopy, Differential interference contrast (DIC) microscopy, Fluorescence Microscopy,
   - Commonly used fluorophores and selection of fluorophore combinations for fluorochromes for colocalization studies
   - Confocal & super-resolution Microscopy, Electron Microscopy (SEM and TEM), Atomic force microscopy, Cryogenic electron microscopy (cryo-EM).

III. **Microscopy-based techniques and applications**
   - Live Cell imaging, Fluorescence recovery after photobleaching (FRAP), Fluorescence Resonance Energy Transfer (FRET), Fluorescence Lifetime Imaging Microscopy (FLIM)
   - Digital imaging, image processing, and analysis.

Content (Practical)

Designed in a hybrid mode to blend theory, virtual learning with hands-on experience

I. Microscopy: Principles and applications
   - A virtual tour of the history of development of microscopy
   - Virtual module introducing the properties of light, image formation, and resolution using interactive simulations.
   - Hands-on session to identify and understand the function of various components of modern microscopes.
   - Demonstration of different types of objective lenses and their impact on magnification and resolution.
   - Virtual demonstration on identifying and correcting common optical aberrations using alignment tools and calibration slides.

II. Basic knowledge of principles and applications of different microscopy types
   - In-lab training on bright-field, dark-field, and phase-contrast microscopy using biological specimens.
   - Guided hands-on session in fluorescence microscopy: fluorophore selection, filter cube handling, and image capture.
   - Confocal microscopy demonstration (live or recorded), including z-stack image acquisition and 3D reconstruction.
   - Introduction to advanced imaging systems—SEM, TEM, AFM, Cryo-EM—through virtual lab tours or expert video lectures and visit to facilities

III. Microscopy-Based Techniques and Applications
   - Virtual module of live cell imaging, sample preparation and visit to facility for demonstration

- Demonstration and data analysis of advanced techniques such as FRAP, FRET, and FLIM using shared image datasets.
- Practical training in digital image processing using ImageJ/Fiji for tasks such as quantification, colocalization, and enhancement.
- Case studies and group discussions integrating microscopy-based techniques with real biological research problems.

Suggested Reading

1.	Adventures with a Microscope	Headstrom R	Dover Publications, USA
2.	Introduction to Optical Microscopy	Mertz J	Roberts & Company Publishers, USA
3.	Fundamentals of Light Microscopy and Electronic Imaging	Murphy DB	Wiley & Sons Publication, USA
4.	Basic Methods in Microscopy: Protocols and Concepts from Cells: A Laboratory Manual	Spector DL & Goldman RD	CSHL Press, USA
5.	Fluorescence Microscopy: From Principles to Biological Applications	Ulrich Kubitscheck	Wiley VCH
6.	Adventures with a Microscope	Headstrom R	Dover Publications, USA
7.	Handbook of Biological Confocal Microscopy	James Pawley	Springer-Verlag New York Inc
8.	Confocal Microscopy for Biologists	Alan R. Hibbs	Springer-Verlag New York
9.	Single-particle Cryo-EM of Biological Macromolecules	Glaeser et al.	Institute of Physics Publishing
10	https://www.microscope.healthcare.nikon.com/		
11	https://www.olympus-global.com/technology/museum/micro/		
12	https://www.zeiss.com/microscopy/en/about-us.html		
13	https://www.leica-microsystems.com/		
14	Relevant Review and Research Papers		

Snapshot of proposed courses for Semester 3 & 4 under various structures (subject to final approval from Academic Committee/ Executive Council)

Structure 1 (only Coursework) (content and codes are proposed, not final)

Semester 3			
GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
GEN-302	DSC/4	Experiential learning in Genetics – III	
GEN-303	DSE/4	Microbial Genetics	Option of any 3 DSE or 2 DSE+1 GE (GE offered by other departments)
GEN-304	DSE/4	Plant Genetics & Breeding	
GEN-305	DSE/4	Human Genetics	
PMB/GEN	DSE/4	Bioinformatics	
GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
GEN-311	2CC/2	Computational Biology	Compulsory
Semester 4			
GEN-401	DSC/4	Population and Quantitative Genetics	Compulsory
GEN-402	DSC/4	Application of genetic studies in clinical research and plant biotechnology	
GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 3 DSE or 2 DSE+1 GE (GE offered by other departments)
GEN-404	DSE/4	Biology of Dictyostelium	
GEN-405	DSE/4	Cancer Biology and Genetics	
GEN-406	DSE/4	Genetics of plant-microbe interaction	
GEN-407	DSE/4	Yeast genetics	
GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
GEN-411	2CC/2	Scientific Writing	Compulsory

Structure 2 (Coursework + Research) (content and codes are proposed, not final)

Semester 3			
GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
GEN-303	DSC/4	Microbial Genetics	
GEN-304	DSE/4	Plant Genetics & Breeding	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
GEN-305	DSE/4	Human Genetics	
PMB/GEN	DSE/4	Bioinformatics	
GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
GEN-312	RP/6	Research Project	Compulsory
Semester 4			
GEN-401	DSC/4	Population and Quantitative Genetics	Compulsory
GEN-402	DSC/4	Application of genetic studies in clinical research and plant biotechnology	
GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 2 DSE or 1 DSE+1 GE (GE offered by other departments)
GEN-404	DSE/4	Biology of Dictyostelium	
GEN-405	DSE/4	Cancer Biology and Genetics	
GEN-406	DSE/4	Genetics of plant-microbe interaction	
GEN-407	DSE/4	Yeast genetics	
GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
GEN-412	RP/6	Research Project	Compulsory

Structure 3 (Research) (content and codes are proposed, not final)

Semester 3			
GEN-301	DSC/4	Principles of Genetic analysis	Compulsory
GEN-303	DSE/4	Microbial Genetics	Option of any 1 DSE or 1 GE (GE offered by other departments)
GEN-304	DSE/4	Plant Genetics & Breeding	
GEN-305	DSE/4	Human Genetics	
GEN-310	GE/4	Genetics in Human Health (offered only to students of other departments)	
PMB/GEN	2CC/2	Bioinformatics I: Introduction to databases and sequence analysis (SR)	Compulsory
PMB/GEN	TR/2	Bioinformatics II: Genomics and Structural Biology (SR)	Compulsory
GEN-312	RP/10	Research Project	Compulsory
Semester 4			
GEN-403	DSE/4	Advances in Drosophila genetics	Option of any 1 DSE or 1 GE (GE offered by other departments)
GEN-404	DSE/4	Biology of Dictyostelium	
GEN-405	DSE/4	Cancer Biology and Genetics	
GEN-406	DSE/4	Genetics of plant-microbe interaction	
GEN-407	DSE/4	Yeast genetics	
GEN-410	GE/4	Basic Science to Biological Applications (offered only to students of other departments)	
GEN-412	RP/16	Research Project	Compulsory