























Semester IV				
Number of core courses (2)	Credits in each core course			
Course	Theory	Practical	Tutorial	Credits
GENCC401 Developmental Biology and Immunology	4	0	0	4
GENCC402 Project Work	0	12	0	12
Total credits in core courses	4	12	0	16
Number of elective courses (2 out of 7 offered)	Credits in each elective course			
Course	Theory	Practical	Tutorial	Credits
GENEC403 Advances in <i>Drosophila</i> Genetics	4	0	0	4
GENEC404 Biology of <i>Dictyostelium</i>	4	0	0	4
GENEC405 Cancer Biology and Genetics	4	0	0	4
GENEC406 Genetic Counselling	4	0	0	4
GENEC407 Genetics of Plant-Microbe Interactions	4	0	0	4
GENEC408 Non-coding RNA Biology, Gene silencing and applications	4	0	0	4
GENEC409 Yeast Molecular Genetics	4	0	0	4
Total credits in elective courses	8	0	0	8
Total credits in Semester I/II/III/IV: 24 + 24 + 24 + 24 = 96				

### Selection of Elective Courses:

Students are free to choose 2 out of the 7 elective courses that are being offered. There are no prerequisites for the choice.

**Open Elective:** The open elective course will be offered for all students.

### Teaching:

The faculty of the Department is primarily responsible for organizing lectures for the offered courses. Some courses will be taught by faculty of sister departments or guest faculty from other institutes. For some topics special lectures could also be arranged. The outline of the teaching program will be made available to students in the beginning of the semester by individual faculties.

Supervisors for the project work will be based on draw of lots. The students are expected to make two presentations, and submit a detailed report of the work carried out.

### Eligibility for Admissions:

Students of B.Sc. (General) or B.Sc. (Hons.) or an equivalent undergraduate degree in any branch of life-sciences/physical-sciences/chemical-sciences/mathematical-sciences/medical-

sciences/pharmacology/any branch of biology/paramedical sciences. The candidate should have scored 60% (or equivalent CGPA score) marks in their main subject (for Hons. stream) or in aggregate (for B.Sc General) or other equivalent undergraduate degree. Relaxation in eligibility will be as per university guidelines.

Admission in M.Sc. (Genetics) is through an entrance test consisting of Multiple Choice Questions based on various sub-disciplines of biological sciences (B.Sc. level) i.e. Botany, Zoology, Biochemistry, Microbiology, Biotechnology etc. with emphasis on Genetics. Some questions from basics in Chemistry, Physics, Mathematics and General Awareness may also be included.

### **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.
  - iv. The scheme of examination will be as follows:

Paper Code	Name of Paper	Duration of examination	Total marks	Credits
<b>SEMESTER I</b>				
GENCC101	Introduction to Genetic Analysis	3 hrs	100	4
GENCC102	Chromosomes, Genes and Genomes	3 hrs	100	4
GENCC103	Cell Biology	3 hrs	100	4
GENCC104	Molecular Biology	3 hrs	100	4
GENCC105	Experiments in Genetics – I (Practicals)	16 hrs (over 2 days)	200	8
Semester I: Total			<b>600</b>	<b>24</b>
<b>SEMESTER II</b>				
GENCC201	Population, Evolutionary and Quantitative	3 hrs	100	4

	Genetics			
GENCC202	Bioinformatics and Biostatistics	3 hrs	100	4
GENCC203	Regulation of Gene Expression	3 hrs	100	4
GENCC204	Recombinant DNA Technology	3 hrs	100	4
GENCC205	Experiments in Genetics –II (Practicals)	12 hrs (over 2 days)	100	4
GENOE206	Genetics in Crop Improvement and Human Health	3 hrs	100	4
Semester II: Total			<b>600</b>	<b>24</b>
<b>SEMESTER III</b>				
GENCC301	Microbial Genetics	3 hrs	100	4
GENCC302	Human Genetics	3 hrs	100	4
GENCC303	Plant Genetics and Breeding	3 hrs	100	4
GENCC304	Plant Tissue culture and Transgenic technology	3 hrs	100	4
GENCC305	Experiments in Genetics –III (Practicals)	16 hrs (over 2 days)	200	8
Semester III: Total			<b>600</b>	<b>24</b>
<b>SEMESTER IV</b>				
GENCC401	Developmental Biology and Immunology	3 hrs	100	4
GECC402	Project work	-	300	12
GENEC403 to GENEC409	Elective course 1	3 hrs	100	4
GENEC403 to GENEC409	Elective course 2	3 hrs	100	4
Semester IV: Total			<b>600</b>	<b>24</b>
<b>Course Total</b>			<b>2400</b>	<b>96</b>

### Pass Percentage & Promotion Criteria:

Pass percentage: The student is required to pass separately both in theory and laboratory-based examinations. Minimum marks for passing the examination shall be 45% in aggregate in theory courses, 45% in laboratory courses and 45% marks in dissertation. The student must score at least 40% in each theory paper.

Promotion criteria from semester to semester: Within the same Part, the candidate will be promoted from one semester to the next (Semester I to Semester II and Semester III to Semester IV), provided the candidate has passed at least two of the papers of the current semester by securing at least 40% marks in each paper.

Note: A candidate will not be allowed to reappear (even if he/ she is absent) in the practical examination except in very special cases with approval of Head of the Department.

### **Part I to Part II Progression:**

Admission to Part II of the program shall be open to only those students who have fulfilled the following criteria:

1. Have scored at least 45% marks in the laboratory courses of both Semester I and II
2. Have passed at least 75% of the theory papers (6 papers) offered in courses of Part I comprising of Semester I and Semester II by securing at least 40% marks in each of these six papers and
3. Have secured at least 45% in aggregate of all theory papers of Part I.

Note: The candidate however will have to clear the remaining papers while studying in Part II of the programme in order to qualify for the receipt of a Master's degree.

**Conversion of Marks into Grades:** As per university norms

**Grade Points:** As per university norms

**CGPA Calculation:** As per university norms

**SGPA Calculation:** As per university norms

**Grand SGPA Calculation:** As per university norms

**Conversion of Grand CGPA into Marks** As per university norms

**Division of Degree into Classes:** As per university norms

**Attendance Requirement:** As per university norms

**Span Period:** As per university norms

### **Guidelines for the Award of Internal Assessment marks:**

Will follow university norms. We have currently proposed:

- 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.
- iii. This will be uniformly followed in all semesters.

**IV: Course-wise Content Details for M.Sc Genetics Programme**  
**Master's in Genetics**  
**Semester I**

**GENCC101: INTRODUCTION TO GENETIC ANALYSIS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objectives:**

The science of Genetics has come to occupy a pivotal position in the entire field of Biology, as it is central to numerous aspects of human affairs. Deeply rooted in strong concepts, it has provided the unifying themes for all living organisms. While on one hand, the science centers around a phrase “like begets like”, it also explains the inherent variability that differentiates one individual from the other. Though the discipline of Genetics has moved far ahead from simple inheritance of the characters, it is absolutely essential to have a clear understanding of the underlying concepts. This paper deals with these basic concepts that form the building block for any further understanding of genetics.

**Course Learning Outcomes:**

**CO1:** Students will be able to comprehend the fundamentals of genetics.

**CO2:** Will be able to develop strategies to create genetic variation as well as methods for analyzing the existing ones.

**CO3:** Students will be able to analyze the different patterns of inheritance observed across biological systems

**CO4:** Students will understand the various strategies employed to map a gene in different model systems.

**Contents:**

**Unit I** [8]

**Genetic basis of life**

Sexual life cycles, meiosis leading to segregation and independent assortment; Reading: Mendel's paper on “Experiments in Plant Hybridization” (1865); introduction to the concept of probability in genetic analysis.

**Unit II** [6]

**Genetic variations**

Sources of genetic variation: mutations, recombination (including models of recombination), independent assortment; analyzing genetic variation by using markers: phenotypic, biochemical and molecular (isozymes and DNA markers).

### Unit III

[22]

#### Analyzing inheritance patterns

Single gene inheritance pattern: allelic interactions; sex-linkage; penetrance and expressivity; test for allelism-complementation; Inheritance of two genes: independent assortment versus linkage, gene; Introduction to quantitative traits: Continuous and discontinuous variation: polygenic inheritance; genetic variance, heritability interactions; Pedigree analysis in humans; Extranuclear inheritance.

### Unit IV

[24]

#### Genetic analysis and mapping in model systems

*E. coli* and its phages: temporal and recombination-based mapping in *E. coli*, transformation and transduction-based mapping, gene mapping in bacteriophage; *Neurospora* and *Aspergillus nidulans*: tetrad analysis and parasexual recombination; *Drosophila* – mapping by recombination, based on test cross and F<sub>2</sub> progeny; Fine structure mapping (Experiments of Seymour Benzer); Physical versus genetic maps; an overview on strategies of genetic analysis in *Caenorhabditis elegans*, mouse etc.

#### Suggested readings\*:

- |   |                           |                   |
|---|---------------------------|-------------------|
| 1. Introduction to Genetic Analysis     | Griffith AF <i>et al.</i> | W H Freeman & Co  |
| 2. Concepts of Genetics                 | Klug WS&Cummings MR       | Prentice-Hall     |
| 3. Genetics – a conceptual approach     | Pierce BA                 | W H Freeman & Co  |
| 4. Principles of Genetics               | Sunstad DP & Simmons MJ   | John Wiley & sons |
| 5. Genetics                             | Strickberger MW           | Prentice-Hall     |
| 6. Genetics Analysis of Genes & Genomes | Hartl, D.L. Jones, E.W.   | Jones & Barlett   |
| 7. Genetics: A Molecular Approach       | Peter J Russel            | Pearson           |
| 8. Genetic Analysis                     | Phillip Meneely           | Oxford            |

*\*The specific edition of the books listed under suggested readings in all papers of the course is not mentioned. This is to enable the students to get greater clarity on some of the original thoughts detailed in the earlier editions which may have been omitted /concised in the subsequent ones providing updates on the subject. The students will be guided towards particular editions during teaching.*

**The teaching plan and assessment tasks for this and all subsequent papers will be made available to the students by the concerned faculty at the beginning of each semester.**



**Master's in Genetics  
Semester I**

**GENCC102: CHROMOSOMES, GENES AND GENOMES**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

This paper has been designed to provide fundamental and advanced aspects of chromosome biology, genome organization, concept and mapping of gene, and outshoots. The students are expected to develop a holistic notion about the dynamic nature of chromosome and its influence in regulating various aspects of cellular functioning and organism as 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.

**Course Learning Outcomes:**

- CO1:** To equip the students with the information of various classical and contemporary techniques and their applications to study in-depths of cells and chromosomes.
- CO2:** To develop an understanding about the structure and organization of the dynamic chromosomes, and to also study about various chromosomal anomalies and their consequences on cellular functioning.
- CO3:** To become aware of the various essential classical and contemporary approaches and methods to study chromosome, genes and genome, and to also develop conventional and modern concept of gene.
- CO4:** To understand the dynamic role and involvement of chromosomes during various stages of cell division, and to comprehend the genetic control of mitosis and meiosis.
- CO5:** To cultivate perception about various features of genome organization in prokaryotic and eukaryotic organisms, and to appreciate the diversity and contribution of transposable elements in genome evolution.
- CO6:** To develop concept about chromosomal aspects of sex determination in animal and plants, and to become aware of the strategies involved in achieving dosage compensation in various organisms.

**Contents:**

**Unit I**

[4]

**Methods to study cells and chromosomes**

An overview of various microscopy methods and applications, centrifugation techniques, fractionation, spectrophotometry, autoradiography techniques.

## **Unit II**

[16]

### **Chromatin structure**

Histones, DNA, nucleosome morphology and higher level organization, Functional states of chromatin and alterations in chromatin organization.

### **Chromosome 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, Chromatin remodeling.

### **Giant chromosomes**

Polytene and lampbrush chromosomes, and their biological significance.

### **Chromosomal anomalies**

Overview of numerical and structural alterations, and their impact on cellular functioning and development, induced chromosomal aberrations in somatic cells.

## **Unit III**

[12]

### **Methods to study chromosome 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, premature chromosome condensation.

### **Concept of gene**

Conventional and modern views, fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families.

## **Unit IV**

[8]

### **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.

## **Unit V**

[12]

### **Genome organization**

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.

## Unit VI

[8]

### Sex determination

Genetic determination of sex in *Caenorhabditis elegans*, *Drosophila melanogaster*, mammals and flowering plants.

### Dosage compensation

Various approaches of dosage compensation in *Caenorhabditis elegans*, *Drosophila melanogaster* and mammals.

### X chromosome inactivation

Lyon's hypothesis, genetic control of X-chromosome inactivation.

### Suggested readings:

- |    |  |                             |                         |
|----|--|-----------------------------|-------------------------|
| 1. | Essential Cell Biology                         | Alberts B <i>et al.</i>     | Garland<br>Publishing   |
| 2. | Molecular Biology of the Cell                  | Alberts B <i>et al.</i>     | Garland<br>Publishing   |
| 3. | The Eukaryotic Chromosome                      | Bostock CJ &<br>Summer AT   | Elsevier                |
| 4. | The Chromosome                                 | Harrison HJS & Flavell RB   | Bios                    |
| 5. | Advanced Genetic Analysis                      | Hawley RS & Walker MY       | Blackwell<br>Publishing |
| 5. | Structure & Function of Eukaryotic Chromosomes | Hennig W                    | Springer                |
| 6. | Genes IX                                       | Lewin B                     | Pearson                 |
| 7. | Molecular Cell Biology                         | Lodish <i>Het al.</i>       | Freeman                 |
| 8. | Cell and Molecular Biology                     | DeRobertis &<br>De Robertis | Lippincott<br>& Wikins  |
| 9. | Genome 3                                       | Brown TA                    | Garland<br>Publishing   |

**Master's in Genetics  
Semester I**

**GENCC103: CELL BIOLOGY**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objectives:**

Life on this earth has evolved through a set of simple biochemical reactions, which has subsequently given rise to specific cell types. Cells are made out of some building blocks which when bonded together produce the various structural and functional constituents. The paper will also discuss the transport of biomolecules in eukaryotes, turnover of regulatory molecules, crosstalk between basic processes and cell cycle, basics on signaling pathways and programmed cell death.

**Course Learning Outcomes:**

**CO1:**Introduction of biomolecules necessary for building and sustenance of the cell

**CO2:**This section deals with understanding the overall establishment of cellular architecture, transport of macromolecules with the cells and its regulation

**CO3:** Introduction to protein structure-function, folding and degradation

**CO4:**This unit will give fundamentals of cell division, cell signaling and their controls

**Contents:**

**Unit I:** [6]

**Biomolecules**

Chemical bonds; Building blocks- carbohydrates, lipids, fats, proteins, nucleic acids.

**Cellular energetics**

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

**Unit II** [18]

**Cell structure and organization**

Plasma membrane; Fluid mosaic model; Nuclear organization, Information compartment; ER and Golgi, Cytoskeleton, Mitochondria and Chloroplast.

**Trafficking of biomolecules**

mRNA transport, Nucleo-cytoplasmic transport; Transport into ER, Mitochondria; Secretory pathways; Protein sorting; Endocytosis; Unfolded protein response; Cholesterol homeostasis-cellular transport, regulation of biosynthetic genes.

### Unit III

[16]

#### Proteins

Protein structure; Primary, Secondary, Tertiary and Quaternary; Protein misfolding, Chaperones; Versatility of proteins in biological processes.

#### Cellular proteolysis

Autophagy, Proteosomes, Ubiquitin pathway.

### Unit IV

[20]

#### Cell cycle and its regulation

#### Cell signalling pathways

Signal molecules, Signalling pathways, Mechanism of signal transduction, Crosstalk among different signalling pathways, Programmed cell death.

#### Suggested readings:

- |    |   |  |                   |
|----|---|--|-------------------|
| 1. | Principles of Biochemistry                              | Lehninger <i>et al.</i>                | W. H. Freeman     |
| 2. | Biochemistry  | Devlin TM                              | Wiley-Liss        |
| 3. | Biochemistry  | Berg JM,<br>Tymoczko JL<br>& Stryer LT | W. H. Freeman     |
| 4. | Molecular Cell Biology                                  | Lodish <i>et al.</i>                   | W. H. Freeman     |
| 5. | The World of the Cell                                   | Becker WM <i>et al.</i>                | Benjamin Cummings |
| 6. | Biochemical Calculation                                 | Seigel IH                              | Wiley             |
| 7. | Cell and Molecular Biology:<br>Concepts and Experiments | Karp G.                                | Wiley             |
| 8. | Molecular Biology of the Cell                           | Bruce Alberts <i>et al.</i>            | Garland           |

**Master's in Genetics  
Semester I**

**GENCC104: MOLECULAR BIOLOGY**

**Marks: 100**

**Duration: 60 Hrs.**

**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. Special emphasis has been given to proteins as biocatalysts, in cellular reactions.

**Course Learning Outcomes:**

- CO1:** Students will learn of the basics of nucleic acid structure and function, mechanisms and molecules governing processes of replication and the advancement in the field will be discussed
- CO2:** To give an account on how and what processes are involved in decoding information from DNA to RNA or Proteins in both prokaryotes and eukaryotes
- CO3:** Students will learn the basic biochemical process and pathways in a cell

**Contents:**

**Unit I** [10]

**DNA as genetic material**

Seminal experiments on its discovery, function, DNA structure and topology.

**DNA in biological processes**

DNA replication; General features of DNA replication; Basic mechanism of DNA replication; Origin of replication and regulation of DNA replication; DNA repair; Types of DNA damage, mechanisms of DNA repair in prokaryotes and eukaryotes – Base excision, nucleotide excision, mismatch repair, double strand break repair, SOS response.

**Unit II** [28]

**RNA as genetic material**

Types of RNA, role of RNA in information transfer, concept of central dogma.

**Gene expression**

Transcription- Gene as a unit of function; RNA polymerases, regulatory sequences, transcription factors, process of initiation, elongation and termination; Post-transcriptional modifications -

capping, poly-adenylation, splicing (*cis*- and *trans*-), other RNA processing events- transfer RNA, RNA editing; Translation-Genetic code, codon usage, ribosome structure, process of translation; Post-translational modifications; Experimental approaches.

### Unit III

[22]

#### Cellular Biochemistry

Enzymes- Their role as biocatalysts, specificity and kinetics, assay and inhibition of enzyme activity, mechanism of action, regulation of enzyme activity, Allosteric enzymes; Biochemical Pathways- Biosynthesis of ATP, Metabolism of carbohydrates, Metabolism of fatty acids, Respiratory chain, Ketone body formation and utilization, Shuttle systems, Regulation and integration of metabolic networks, examples from fasting and starvation, Diabetes mellitus, obesity.

#### Suggested Readings:

- |  |  |                                |
|--|--|--------------------------------|
| 1. Molecular Biology of the Cell                           | Alberts B., Johnson A.,<br>Lewis J., Raff M., Roberts<br>K., Walter P. | Garland Science                |
| 2. Molecular Biology of the Gene                           | Watson J. D., Baker T. A.,<br>Bell S. P., Gann Alexander               | C S H L Press                  |
| 3. Genes X   | Krebs, J. E., Goldstein E.<br>S., Kilpatrick S.T.                      | Jones & Bartlett<br>Publishers |
| 4. Cell and Molecular Biology:<br>Concepts and Experiments | Karp G.  | Wiley                          |
| 5. The Cell: A Molecular<br>Approach                       | Cooper G. M  | Sinauer Associates             |
| 6. Fundamentals of<br>Enzymology                           | Price NC& Lewis ST   | Oxford University<br>Press     |
| 7. Principles of Biochemistry                              | Lehninger <i>et al.</i>  | W. H.Freeman                   |
| 8. Biochemistry  | Devlin TM  | Wiley-Liss                     |
| 9. Biochemistry  | Berg JM, TymoczkoJL &<br>Stryer LT                                     | W. H.Freeman                   |

**Masters in Genetics  
Semester I**

**GENCC105: EXPERIMENTS IN GENETICS – I**

**Marks: 200**

**Duration: 240 Hrs.**

**Course Objectives:**

The objective of this course is to give a hands-on-training to students in experimental skills. This paper will introduce students to designing experiments, performing them and interpreting observations using different model organisms. The students will also get hand-on-training in biochemical experiments.

**Course Learning Outcomes:**

Students will be able to handle different model systems. They will develop the ability of asking questions, designing experiments and carrying the out.

Working with model organisms:

1. Marker characterization and genotype determination in *E. coli* and *Aspergillus nidulans*
2. Analyzing growth of different strains (K12 and XL1Blue) of *E. coli* on
  - i. Complete medium
  - ii. Minimal medium with different carbon sources (glucose, lactose and both together)
3. UV mutagenesis of *E. coli* (continue to semester III)  
Survival response of *E.coli* on UV irradiation  
Induced mutagenesis – Screening and selection
4. Phage titration and preparation of phage lysate
5. Handling, maintaining cultures and study of the life cycle of *Drosophila melanogaster*, an identification and analysis of different mutants lines
6. Studying inheritance patterns (autosomal and sex-linked) by making genetics crosses by utilizing various mutant alleles of *Drosophila*
7. Three point linkage mapping by utilizing *Drosophila* mutant lines (continue to semester II)
8. Preparation of polytene chromosomes from salivary gland of *Drosophila*
9. Growth and development of *Dictyostelium discoideum*
10. Visit to facilities, to introduce students to model organisms like *Arabidopsis*, zebra fish, *Caenorhabditis elegans*.
11. Study of mitosis (onion root tip), meiosis (onion or Rhoeo buds) and chromosomal aberrations

Basic experiments in Biochemistry

12. To plot the titration curve for acetic acid and to calculate the buffering zone
13. To prepare an acetate buffer of pH 5.0
14. To plot titration curve for sodium dihydrogen phosphate ( $\text{NaH}_2\text{PO}_4$ )
15. To find the molar extension coefficient of PNP
16. To plot a standard curve for estimation of protein using Folin-lowry method



17. To assay the activity of the enzyme acid phosphatase in extract of moong dal and to determine its specific activity
18. To study the effect of varying substrate concentration on the activity of the enzyme acid phosphatase
19. To estimate total protein from moong daal sprout in various subcellular fractions
20. To purify the enzyme acid phosphatase using ion exchange chromatography
21. Analyzing proteins in non-denaturing (e.g., serum G6PD) and denaturing SDS-PAGE (recombinant protein)
22. Introduction to different instruments and analytical techniques (microscopy, centrifugation, spectroscopy)

## Master's in Genetics

### Semester II

#### GENCC201: POPULATION, EVOLUTIONARY AND QUANTITATIVE GENETICS

**Marks: 100**

**Duration: 60 Hrs.**

#### Course Objective:

Population genetics is necessary to comprehend the students about the evolutionary processes in the natural populations. It will make the students familiar with different types of genetic markers and their detection to enable advanced molecular population genetic studies. It will also make them understand the forces that have an impact on levels of genetic variations in natural and/or experimental populations for both qualitative and quantitative traits.

#### Course Learning Outcomes:

**CO1:** To comprehend the sources of genetic variation and methods for detecting these variations at both morphological and molecular level.

**CO2:** To make students understand the genetic organization and measure the genetic variation of different types of genes in a natural population.

**CO3:** To understand the importance of genetic mapping in natural populations.

**CO4:** To know different types of natural populations and their genetic characteristics.

**CO5:** To know and quantify the different types of evolutionary forces which bring changes in the gene frequencies in biological population.

**CO6:** To appreciate different theories of evolution and their molecular mechanism.

**CO7:** To understand the importance of quantitative traits and how to estimate their genetic effects.

#### Contents:

##### Unit I

[8]

##### Genetic variation

Types and sources of variation; Mechanisms of mutation; Detection of polymorphism – DNA markers and their detection techniques

##### Unit II

[10]

##### Organization and measurer of genetic variation

Random mating population; Hardy-Weinberg principle; Complications of dominance; Special cases of random mating – multiple alleles, sex-linked genes

**Unit III** [8]

**Linkage and Linkage disequilibrium**

Definition of linkage disequilibrium and the difference between linkage and linkage disequilibrium;  
Different parameters to estimate linkage disequilibrium

**Unit IV**

**Population sub-structure** [4]

Hierarchical population; Isolate breaking; inbreeding, assortative and non-assortative mating

**Unit V**

**Gene frequencies and evolution** [8]

Mutation; selection; migration; genetic drift

**Unit VI** [12]

**Molecular evolution**

Theories of evolution; neutral theory and coalescence; molecular evolution of genes and proteins;  
Phylogeny and systematics

**Unit VII**

**Quantitative genetics** [10]

Johannsen pure line theory; Multiple factor hypothesis; Types of quantitative traits; Components of phenotypic variation and genetic models of quantitative traits; Concept of heritability

**Suggested readings:**

- |   |                           |                      |
|---|---------------------------|----------------------|
| 1. DNA Markers: Protocols<br>Applications and Overviews     | Anolles GC & Gresshoff PM | Wiley-Liss           |
| 2. Molecular Markers in Plant<br>Genetics and Biotechnology | Vienne De D               | Science Publishers   |
| 3. Genetics of Population                                   | Hedrick PW                | Jones & Bartlett     |
| 4. Principles of Population<br>Genetics                     | Hartl DL& Clark AG        | Sinauer Associates   |
| 5. Biostatistics  | Danial WW                 | Wiley                |
| 6. Statistical Methods in Biology                           | Bailey NTJ                | Cambridge Univ.Press |

**Master's in Genetics**

**Semester II**

**GENCC202: BIOINFORMATICS AND BIOSTATISTICS**

**Marks: 100**

**Duration: 60 Hrs.**

**BIOINFORMATICS**

**Course Objective:**

This course is aimed at imparting knowledge of application of computational methods in order to address biological problems.

**Course Learning Outcomes:**

**CO1:** Students will be able to work with public sequence repositories and use database search tools like BLAST to search similar sequences.

**CO2:** Students will be aware of concepts of homology and can understand select appropriate tools to perform phylogenetic analysis.

**CO3:** After attending the course students will be aware of the concepts of annotation of different features of genomes.

**CO4:** To be able to compare and classify biomolecules on the basis of structure for gaining insight into their function.

**CO5:** To be able to differentiate between the utility of various methods available for generating a model of protein structure.

**CO6:** To be able to relate the basic concepts of bioinformatics to the application in public health.

**Contents:**

**Unit I**

[6]

**Databases and Sequence formats**

Nucleotide and protein sequence databases - Uniprot, Swissprot, PIR. Genbank, Refseq; The NCBI resources (Entrez, Boolean search terms and statements, NCBI bookshelf); Introduction to nucleotide and protein sequence data formats - FASTA, GenBank, Flatfiles, Genome annotation methods

**Unit II**

[6]

**Pair-wise Alignment and Database Searching**

Scoring matrices, local and global alignment, scoring functions, data base search for homologous sequences (FASTA and BLAST), motifs and domain searching; notion of homology orthologues, paralogues, analogues

### **Multiple Sequence Alignment**

Sum of Pairs measure, Clustal W, Clustal X, progressive alignment, scoring MSAs, iterative methods of MSA

**Unit III** [4]

### **Molecular Phylogenetics**

Concept of evolutionary trees - Branches, nodes, internal nodes, rooted and un-rooted trees; Different methods and tools for phylogenetic analysis (UPGA, NJ, Maximum Parsimony & Maximum Likelihood); Bootstrapping evaluation

**Unit IV** [8]

### **Biomolecular structures**

Protein structure determination methods (X-Ray crystallography & NMR), Protein structure and classification databases, Characteristics of Nucleic acid structure, Structural RNA like tRNA, Small and non-coding. RNA

**Unit V** [8]

### **Basics of Molecular Modeling**

Basic principles of tertiary structure prediction, homology modeling, threading and ab-initio protein structure prediction, Protein structure comparison, Superimposition and RMSD calculations

**Unit VI** [8]

### **Current Topics and Advances in Bioinformatics**

Next-Generation Sequencing Technologies and their applications in Pharmacogenomics, Genomic Medicine, Epigenomics and Metagenomics.

#### **Suggested Readings:**

- |  |                                    |                              |
|--|------------------------------------|------------------------------|
| 1. Proteomics- from protein structure function                             | Dunn M J                           | Viva Publisher               |
| 2. Introduction to Bioinformatics  | Lesk A                             | OUP- India                   |
| 3. Essential Bioinformatics  | Jin Xiong                          | Cambridge Univ. Press        |
| 4. Bioinformatics: Sequence and genome analysis                            | David mount                        | Cold Spring Harbor Lab Press |
| 5. Bioinformatics: A practical guide to the analysis of genes and proteins | Baxevanis & Outlette (Eds.)        | John Wiley & Sons Inc.       |
| 6. Microarray Bioinformatics   | Dov Stekel                         | Cambridge Univ.Press         |
| 7. Structural Bioinformatics   | Jenny Gu & Philip E. Bourne (Eds.) | Wiley-Blackwell              |

## **BIOSTATISTICS**

### **Course Objective:**

Much of genetic analysis is based on quantitative data and therefore statistical techniques are used extensively. Some basic tools of statistics are essential in designing and analysis of data and in the interpretation of experimental results for dependable conclusion, essential to test a hypothesis.

### **Course Learning Outcome:**

**CO1:** The student will be able to apply and comprehend the usage of basic concepts of commonly used statistical analysis in research applications.

### **Contents**

#### **Unit I**

[20]

#### **Principles and applications of statistical methods in biological research**

Basic statistics- Samples and populations, experimental design, data analysis, graphs, average, coefficient distributions (chi-square, binomial, poisson and normal); Tests of statistical significance – t-test, z-test, F-test, U-test and others; Regression and correlation; Analysis of variance (ANOVA); Introduction to R-package.

### **Suggested readings:**

- |    |                                |            |                       |
|----|--------------------------------|------------|-----------------------|
| 1. | Biostatistics                  | Daniel WW  | Wiley                 |
| 2. | Statistical Methods in Biology | Bailey NTJ | Cambridge Univ. Press |

**Master's in Genetics**

**Semester II**

**GENCC203: REGULATION OF GENE EXPRESSION**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objectives:**

Gene expression is regulated at various stages of transcription, translation and post-translation. These topics would be taught with emphasis on discoveries, examples and experimental designs for studies. Epigenetic regulation is also a fast emerging field which has now been recognized to contribute immensely in developmental processes. Overall, students are expected to read, research and discuss papers related to topics

**Course Learning Outcomes:**

**CO1:** Enable students to discern the broad strategies used by different organisms to regulate expression of genes.

**CO2:** Enable students to analyze the ways by which genes are regulated in bacteria and yeast.

**CO3:** Enable students to analyze the ways by which genes are regulated in eukaryotes

**CO4 & 5:** Students will be able to discern the broad strategies used by different organisms for epigenetic regulation and utilize them for analysis.

**Contents**

**Unit I** [4]

**Strategies in gene regulation**

An overview on the levels of regulation – evidences and experimental designs to study regulation at different levels; concept of positive and negative regulators and building inducible and repressible systems using these components; tools to analyze activity of genes.

**Unit II** [14]

**Lessons from bacteria and yeast**

Jacob and Monod's seminal paper; Analyzing gene regulation with examples from *lac*, *trp* and *ara* operons; Genetic switch for lysis and lysogeny in  $\lambda$  phage; Global control by sigma factors; *GAL1* in yeast.

**Unit III** [8]

**Gene regulation in eukaryotes**

Perceiving signals- overview of cell signaling pathways; analyzing transcriptional control using examples of constitutive, inducible and tissue specific promoters; post-transcriptional regulation with examples of alternative splicing, RNA editing, mRNA stability and degradation; translational regulation- initiation, codon usage; post-translational modifications; control by small RNA.

## Unit IV

[18]

### An introduction to epigenetics

Concept and overview of epigenetics; Chemical changes - DNA methylation and histone modification in determining the chromatin structure; DNA binding proteins; Techniques for studying epigenetic modifications; Polycomb and Trithorax group of proteins; Histone variants in chromosomal inheritance and in stress; Chromatin remodelers, their families and functions; Position Effect Variegation, Heterochromatin spreading and gene silencing in *Drosophila*.

## Unit V

[16]

### Epigenetic events in biology

Genomic imprinting in humans; Imprinting defects in humans; Transgenerational inheritance in mammals; Vernalization in plants; Non coding RNA and X chromosome inactivation; miRNA and cell fate in *Caenorhabditis elegans*; Heterochromatin and mating types in *Saccharomyces cerevisiae*; Cellular memory and homeotic transformations in various organisms; Stem cell reprogramming.

### Suggested readings:

- |    |                                   |                               |                   |
|----|-----------------------------------|-------------------------------|-------------------|
| 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 <i>lac</i> operon             | Benno Muller-Hill             | Walter de Gruyter |
| 5. | Genes                             | Benjamin Lewin                | Prentice Hall     |
| 6. | Molecular Cell Biology            | Lodish H <i>et al.</i>        | W.H Freeman       |
| 7. | Molecular Biology of the Cell     | Alberts B <i>et al.</i>       | Garland Science   |
| 8. | Epigenetics                       | David Allis C                 | CSHL Press        |
| 9. | Classic papers in gene regulation |                               |                   |



**Master's in Genetics**

**Semester II**

**GENCC204: RECOMBINANT DNA TECHNOLOGY**

**Marks: 100**

**Duration: 60 Hrs.**

**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). Looking at the vast implications, topics on bioethics and biosafety, implicit in such a technology have also been covered in this paper.

**Course Learning Outcomes:**

- CO1:** To understand various methods to analyze nucleic acids and proteins by contemporary genetic engineering approaches.
- CO2:** Students would develop basic concepts of gene cloning, construction of various libraries and gene identification.
- CO3:** To become aware of the various essential classical and contemporary approaches to study gene expression by polymerase chain reaction (PCR), hybridization and sequencing based techniques.
- CO4:** To become aware of contemporary strategies and methods to engineer and express recombinant proteins, techniques to study the dynamics of protein- protein and protein-DNA interaction and proteome analysis
- CO5:** To understand several modern gene editing techniques and to appreciate the importance and application of recombinant DNA technology in biology.

**Contents:**

**Unit I**

**Methods of DNA, RNA and protein analysis:**

[8]

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.

## **Unit II**

### **Gene cloning and identification**

[18]

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.

## **Unit III**

### **Expression Analysis**

[14]

Analysis of gene expression: Northern blotting, RT-PCR, EST analysis, Promoter analysis; Mapping transcriptional start sites, Transcriptome analysis – cDNA- and oligo arrays; Serial Analysis of Gene Expression (SAGE); Polymerase Chain Reaction (PCR)- Concept of PCR, various kinds of PCR, Real Time PCR, Ligation Chain Reaction; Applications of PCR.

## **Unit IV:**

[16]

### **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, gel retardation assay, DNase I footprinting, Yeast two and three-hybrids assay; ChIP on chip assay; Split and reverse hybrids, Co-immuno precipitations; Phage display.

## **Unit V**

[4]

### **Applications of recombinant DNA technology in biology and medicine**

Gene editing technologies.

**Suggested readings:**

1. Gene Cloning and DNA Analysis: An Introduction      Brown TA      Blackwell Publications
2. Gene Cloning and Manipulation      Howe C      Cambridge University 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      Wiley Blackwell
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

## Master's in Genetics

### Semester II

#### GENCC205: Experiments in Genetics –II

**Marks: 100**

**Duration: 120 Hrs.**

#### Course Objectives:

The objective of this course is to give a hands-on-training to students in different techniques of recombinant DNA technology and tools used in Bioinformatics. This paper will introduce students to designing experiments on gene expression, performing them and interpreting observations.

#### Course Learning Outcomes:

They will develop the ability of asking questions, designing experiments and carrying them out. They will gain skills of carrying out different recombinant DNA techniques and using tools of Bioinformatics.

#### Experiments on regulation of gene expression

1. Study of gene expression in bacteria using lac operon in *E. coli* as a model
  - i. Biochemical characterization based on  $\beta$ -galactosidase assay
    - a. Induction kinetics
    - b. Difference between wild type and mutants
    - c. Difference under uninduced and induced conditions in the wild type strain
    - d. Difference between glucose and glycerol grown cells of the wild-type strain
2. Analysis of methylation status of a gene and its expression.
3. Quantifying protein expressions by ELISA.

#### Recombinant DNA techniques

4. Primer to recombinant DNA practical.
  - i. Handling micro volumes: use of micropipettes and determining their accuracy by gravimetric method
  - ii. Preparation of dilution of a given DNA sample and measure the absorbance at 260 nm to check accuracy of dilutions.
5. Preparation of competent cells of *E. coli* (XL1-Blue) by  $MgSO_4$ -PEG OR  $CaCl_2$  method and its transformation.
6. Preparation of plasmid DNA by alkaline lysis (mini and midi preparation). Calculating yield and purity of DNA by studying its absorbance and digestion with restriction enzyme.
7. Experiments with agarose gel electrophoresis to analyze relationship between mobility of DNA fragments of different sizes and the percentage of the gel.
8. Digestions and ligation of plasmid DNA. Studying ligations following single digest, double digest and de-phosphorylation.
9. Elution of DNA from agarose gel using elution kit, electro elution.
10. Creating recombinant DNA: directional and non-directional cloning of a DNA fragment in a plasmid vector.

11. Designing primers for a given DNA template and analyzing the role of different reaction components/conditions ( $MgCl_2$  conc., temperature, conc. of template and number of cycles) on the efficiency of PCR.
12. Isolation and digestion of genomic DNA with different restriction enzymes (4, 6 and 8base cutters).
13. Demonstration of Southern hybridization, and DNA sequencing methods.
14. Real time quantification of nucleic acids.

#### Bioinformatics

15. Using NCBI and UniProtKB web resources
16. Similarity searches using tools like BLAST.
17. Multiple sequence alignment using ClustalW
18. Phylogenetic analysis of protein and nucleotide sequences
19. Use of gene prediction methods (GRAIL, Genscan, Glimmer)
20. Use of different protein structure databases (PDB, SCOP, CATH)
21. Visualization/Studying protein structures using Deepview/PyMol
22. Mutating and Energy minimization of protein structures
23. *Ab-initio* structure prediction of proteins
24. Homology modeling of proteins

**Master's in Genetics  
Semester II**

**GENOE206: GENETICS IN CROP IMPROVEMENT AND HUMAN HEALTH**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

This elective paper has been designed to introduce students from other departments to basic concepts in genetics with specific reference to plants and humans. It also aims to provide an overview of the classical and contemporary genetic tools for improvement of overall life quality. The students would develop an inclusive understanding of various breeding and transgenic strategies for improvement of crops. The section on medical genomics would focus on the tools for genetic analysis of human disorders, translation of the findings for predictive, preventive, personalized and participatory (P4) medicine; cellular and animal model of disease for enhanced understanding of disease biology and thereby new therapeutics.

**Course Learning Outcomes:**

**CO1:** Students will be familiarized with the basic concepts underlying inheritance of traits and genetic analysis.

**CO2:** Students will be introduced to the application of various genetic tools, breeding approaches and biotechnology in crop improvement.

**CO3:** The students would develop an inclusive understanding about various genetic approaches to strengthen our understanding about genetic disorders and their management strategies.

**Contents:**

**Unit I** [20]

**Fundamental of Genetics**

Concepts of Mendelian inheritance; Pedigree analysis; Chromosome theory of Inheritance, Concept of gene, allelic and gene interactions, test of allelic complementation; Introduction to linkage, crossing over and developing genetic maps; Cytoplasmic inheritance.

**Unit II** [20]

**Genetics in Crop Improvement**

Crop improvement- Scope, nature and history; Conventional methods for crop improvement - Various breeding strategies; Molecular genetic breeding - Genetic mapping of traits, Marker assisted breeding for important traits (Case study); Application of genetic transformations in crop improvement- case studies of transgenic traits in plant; Biosafety issues.

**Unit III**

[20]

**Genetics in human health**

Introduction to chromosomal, single gene and complex disorders; tools and techniques in the study of genetic disorders – karyotyping, chromosomal banding and analysis, molecular markers, physical and genetic mapping, identification of disease causing gene; epigenetics and human health, nature vs nurture (using twin studies); Human disease modeling in *C. elegans*, *Drosophila*, zebrafish (*Danio rerio*), mouse and its applications; Molecular diagnostics - Prenatal, neonatal and adult diagnosis; Introduction to genetic counseling and ethical, legal and social issues.

**Suggested readings:**

- |    |                                  |                              |                   |
|----|----------------------------------|------------------------------|-------------------|
| 1. | iGenetics A Molecular Approach   | Russell PJ                   | Pearson           |
| 2. | Introduction to Genetic Analysis | Griffith AF<br><i>et al.</i> | W H Freeman & Co  |
| 3. | Human Molecular Genetics         | Strachan T<br>& Read A       | Garland Science   |
| 4. | Principle of Crop improvement    | Simmonds<br>NW &<br>Smart J  | Blackwell Science |
| 5. | Research papers for case studies |                              |                   |

**Master's in Genetics  
Semester III**

**GENCC301: MICROBIAL GENETICS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

Though microorganisms have had a late entry in the field of genetics, once that happened, they quickly occupied the center stage. Combining the structural simplicity with the unifying genetic basis, they offered immediate advantages in studying all the three aspects of heredity: the generation, expression, and transmission of biological variation. This paper deals with the strength of microbial genetics: both prokaryotic as well as eukaryotic.

**Course Learning Outcomes:**

**CO1:** Introduce students to various techniques of gene transfer in bacteria and life cycle of bacteriophages.

**CO2:** Introduce students to life cycle of Yeast, a single cell eukaryote and the different molecular tools available to study various biological processes.

**CO3:** Discussion of primary literature to understand how molecular genetics can be applied in yeast to discover gene function.

**CO4:** Discussion of primary literature to understand how molecular genetics can be applied in bacteria to understand basic process that deal with cell-cell communication.

**Contents:**

**Unit I**

[14]

**Methods used in bacterial genetics**

Conjugation - Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination; Chromosome transfer in other bacteria; Transformation- Natural transformation systems, biology and mechanism of transformation, transformation and gene mapping, chemical-mediated and electro-transformation; Transduction: Discovery, generalized and specialized or restricted transduction, phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction; Temperate phage lambda and mechanism of specialized transduction; Gene mapping, Fine-structure mapping; Techniques for studying bacteriophages- Virulent phage (T4) and temperate phage (phage lambda); Important aspects of lytic cycle, phage-host relationships, immunity and repression; site specific recombination (lambda and P1).

**Unit II**

[12]

**Yeast Biology**

Introduction and an overview of yeast in daily life; Cellular architecture and function; Yeast as an



experimental system for eukaryotic molecular biology.

### **Molecular tools**

Yeast cloning and expression vectors; Regulatable promoters; Construction of genetically modified strains; Generation of conditional alleles; Cosmids and yeast artificial chromosomes; Yeast one-, two- and three-hybrid systems.

### **Unit III**

[22]

#### **Art and design of genetic screens**

Choice of mutant phenotypes; Cloning by complementation; Isolation of bypass and allele specific-suppressors; Synthetic lethal screens; use of these tools to isolate genes in the protein secretion pathway in yeast.

#### **Determination of mating types**

Mating-Type Genes and MAT Switching in *Saccharomyces cerevisiae*; HML, HMR and MAT loci, HO endonuclease, regulation of switching.

### **Unit IV**

#### **Quorum sensing and immunity in bacteria**

[12]

Examples from *Vibrio harveyi* and *Vibrio fischeri*; Regulation of biofilm formation in *Vibrio cholera*; Two component signal transduction system; Discovery of CRISPR-Cas and its role in bacterial immunity.

### **Suggested Reading**

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

**Master's in Genetics  
Semester III**

**GENCC302: HUMAN GENETICS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

Human Genetics is a subject of considerable interest and tremendous relevance to every individual and society. This rapidly growing subject is continuing to revolutionize our early understanding of the basic concepts of genetics, genome organization, gene structure, function and implications for disease. This introductory course attempts to walk the students through classical genetics and molecular genetics with a cautionary endnote on range of ethical, legal and social issues which are also the logical consequences of such unparalleled scientific progress. Beginning with constructing genetic hypothesis from pedigree data and population sampling, application of a variety of conventional and modern tools to test such hypothesis, constraints/ limitations of genetic methodology when applied to humans would be discussed in the early part of the paper. Application of early mapping tools and cloning strategies which culminated in the successful completion of the Human genome project; and the next generation sequencing technologies have now opened up exciting, unimagined scale of discovery genomics and these would be covered next. New/current knowledge on genetic variations in health and disease across populations and their clinical/diagnostic implications would be dealt with subsequently. Considering that purview of medical genetics is now all of medicine and involves ethical issues, this study will remain incomplete without serious discussion on these issues.

**Course Learning Outcomes:**

- CO1:** Gain knowledge of i) the basic conventional and contemporary methodologies which are essential for studying genetics of health and disease; ii) Markers and methods to identify putative disease causing genes- the most important for predictive and preventive medicine/genetic health.
- CO2:** Gain factual knowledge on genetic disorders including chromosomal, single gene and polygenic affecting humans by utilizing the tools as mentioned in CO1.
- CO3:** Gain insights into patterns of human migration, population specific genome architecture and with implications for population specific disease susceptibilities.
- CO4:** Gain knowledge of all the available genetic/molecular diagnostics available for a wide range of disorders which highlight the translational potential and clinical relevance of human genetics research findings. Students can be ready for clinical genetics/medical diagnostics market.
- CO5:** Awareness of the risks and benefits of genetic testing; ethical issues in medical genetics; human rights and societal implications.

**Contents:**

**Unit I** [30]

**Introduction to human genetics**

History; Early perception, development and documentation

**Study tools in human genetics**

Pedigree analysis- Mendelian inheritance and exceptions; Chromosomal analysis (*in vitro*, *in vivo*); Biochemical analysis; Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping); Molecular genetic analysis; Next generation sequencing, target capture, exome sequencing, whole genome sequencing

**Human genome mapping methods**

Physical mapping-Introduction to physical map markers - chromosomal, G/Q - banding, radiation hybrids, Fluorescence *in situ* hybridization; Comparative genome hybridization; Long range restriction mapping; High resolution mapping - STS/EST/MS/SNP/sequencing; Genetic mapping-Linkage analysis (RFLP/MS/SNP); Applications of mapping in normal and disease genome analysis; Gene identification using positional/functional cloning approaches and next generation sequencing technologies

**Human genome analysis**

Conception, mapping, cloning and sequencing; Outcome- generation of ‘OMICS’ era; Significant leads

**Unit II** ..... [14]

**Genetic variation in health and disease**

Chromosomal disorders -Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms – mitotic/meiotic non-disjunction/ chromosomal rearrangements; Some examples (Syndromes/Cancer/ Infertility); Single gene and disease: Inborn errors of metabolism; Haemoglobinopathies; Multifactorial disorders: Introduction; Methods of study (Epidemiological, Twin/adoption and family studies); Etiology - genetic and non-genetic determinants; Common examples; Epigenetics and disease: Mechanisms (Imprinting/methylation; Chromatin remodeling); Current understanding; Some examples; Mitochondrial myopathies

**Unit III** .....[4]

**Human genetic diversity**

Methods of study – Biochemical/molecular genetic markers; Some examples; Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers

## Unit IV

[6]

### Diagnostic genetics

Cytogenetics/Molecular Cytogenetics/Biochemical/Molecular methods; Screening for mutation/chromosomal anomaly - Adult/Prenatal/Newborn screening; Pre-implantation screening (Assisted reproductive technology- *in vitro* fertilization and embryo transfer); Forensic testing - DNA fingerprinting, paternity testing, individual identification

## Unit V:

[6]

### Ethical, legal and social issues in human genetics

Prenatal/Adult (Individual/Family/Population) screening of mutation/risk factor for genetic diseases; Confidentiality/privacy; Discrimination; Ethical dilemma; Human rights; Surrogate mothers; Human cloning and eugenics; Organ banking and transplantation; Research ethics; Medical ethics in India

#### Suggested readings:

- |    |  |                           |                          |
|----|--|---------------------------|--------------------------|
| 1. | Human Genetics: Problems and Approaches                                      | Vogel F & Motulsky A      | Springer Verlag          |
| 2. | Human Molecular Genetics   | Strachan T & Read A       | Garland Science          |
| 3. | An Introduction to Human Molecular Genetics: Mechanism of Inherited Diseases | Pasternak J               | Fitzgerald Science Press |
| 4. | Chromosome Structural analysis: A Practical Approach                         | Bickmore WA (Ed.)         | Oxford University Press  |
| 5. | The AGT Cytogenetics Lab Manual  | Barch, Knutsen & Spurbeck | Lippincott Raven Publ.   |
| 6. | Human Cytogenetics: Constitutional analysis                                  | RooneyDE(Ed.)             | Oxford University Press  |
| 7. | Classical papers in human genetics   |                           |                          |

**Masters in Genetics**

**Semester III**

**GENCC303: PLANT GENETICS AND BREEDING**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

This course primarily deals with how to undertake plant genome analysis and gene mapping through the use of DNA markers and how this information could be utilized in bringing the efficiencies in selection methods of plant breeding and gene isolation by forward genetics approach

**Course Learning Outcomes:**

**CO1:** To make aware the students the importance of plant breeding through giving a historical perspective.

**CO2:** To comprehend the students the natural breeding systems of different agriculturally important plant species used as food and feed.

**CO3:** To make aware the concept of gene pool and the germplasm resources that are fundamental to crop improvement.

**CO4:** To know how chromosomes could be manipulated for genetic improvement of crop plants.

**CO5:** To give a brief knowledge about different breeding methods depending their breeding systems.

**CO6:** To make students understand the genetic and molecular basis of hybrid vigor and how this hybrid vigour could be utilized for developing hybrid varieties.

**CO7:** To expose the students how the different molecular tools particularly DNA markers could be used in genetic analysis and also be used for bringing efficiencies in plant breeding processes.

**Contents:**

**Unit I** [4]

**Historical perspective**

Importance of plant breeding and its history; genetic diversity in plant breeding

**Unit II** [10]

**Natural breeding systems**

Breeding systems in plants and their application in plant breeding

**Unit III** [4]

**Gene pool concept**

Primary, secondary and tertiary gene pools and methods of using them in genetic manipulation

**Unit IV** [8]

**Chromosome breeding**

Haploidy, polyploidy and wide hybridization and their applications in plant breeding; Cytogenetic tools and their application in plant breeding

**Unit V** [8]

**Conventional breeding methods**

Different breeding methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants

**Unit VI** [8]

**Heterosis breeding**

Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties through exploitation of hybrid vigour

**Unit VII** [18]

**Molecular plant genetics and breeding**

Introduction; Molecular markers as efficient tools in plant breeding; Principle of genetic linkage; Concept of genetic distance; Development and choice of mapping populations; Linkage map construction; Integrated and comparative maps; Dissection of quantitative traits - Principles and methods of QTL mapping (linkage and association mapping); Fine mapping of QTL and map-based gene cloning; Marker-assisted breeding - Gene tagging; Marker-aided selection (foreground and background selection); Concept of graphical genotype; Elimination of linkage drags; Marker-assisted recurrent selection (MARS), Genomic Selection (GS)

**Suggested readings:**

- |   |  |                                     |                      |
|---|--|-------------------------------------|----------------------|
| 1 | Plant Breeding theory and practice       | Stoskoff NC, Tomes DT & Christie BR | WestviewPress        |
| 2 | Principle of Crop improvement            | Simmonds NW & Smart J               | Blackwell Science    |
| 3 | Principle of Plant Genetics and Breeding | Aquaah G                            | Blackwell Publishing |
| 4 | Plant Molecular Breeding                 | Newbury HJ                          | Blackwell Publishing |
| 5 | Genome mapping in plants                 | Paterson AH                         | Academic Press       |

**Master's in Genetics  
Semester III**

**GENCC304: PLANT TISSUE CULTURE AND TRANSGENIC TECHNOLOGY**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

The course is designed to provide students with specialized knowledge of the theory and applications of various plant cell and tissue culture technologies as well as the concepts of developing plant transformation vectors and their utilization to develop transgenic plants with new traits for crop improvement and health care.

**Course Learning Outcomes:**

- CO1:** Acquaint with the importance of various components of tissue culture nutrient media and develop skills for preparing nutrient media and plant regeneration procedures.
- CO2:** Gaining practical knowledge in various culture methods and learning their importance in agriculture.
- CO3:** Appreciation and importance of various plant cell and tissue cultures for crop improvement.
- CO4:** Understanding the concepts of vectors and their preparation for plant transformation.
- CO5:** Learning various gene delivery systems in plants for developing genetically modified (GM) plants and their molecular characterization.
- CO6:** To become aware of various potential applications of GM plants in agriculture and health care as well as the regulations and issues in bio-safety of consumption of GM foods.

**Contents:**

**Unit I** [5]

**Plant Tissue Culture Media and Regeneration**

Historical developments; Laboratory organization; Sterilization methods; Nutrient media; Culture conditions; Role of plant hormones and growth regulators in differentiation and development; Plant regeneration pathways - Organogenesis and somatic embryogenesis, Some examples - tobacco, carrot, cotton and rice.

**Unit II** [8]

**Plant Cell and Tissue Culture Methods**

Culture methods for organ, root, ovule, embryo, endosperm, anther and pollen; Callus culture; Cell culture – Batch and continuous cultures; Protoplast isolation, purification and culture, Somaclonal and gametoclonal variation; *In vitro* pollination and fertilization; *In vitro* mutagenesis and mutant selection.

**Unit III** [12]

**Applications of Plant Cell and Tissue Culture Technology**

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

**Unit IV** [6]

**Plant Transformation Vectors**

Historical developments; Tumour inducing principle in *Agrobacterium*- structure and function of Ti-plasmids, Ri-plasmids and T-DNA, Molecular mechanism of T-DNA transfer and integration in the plant genome; Ti-plasmid based co-integrate and binary vectors, RNA silencing vectors.

**Unit V** [12]

**Plant Transformation Methods**

*Agrobacterium* transformation of dicots, monocots and other kingdoms, Agroinfection, Marker and reporter genes; Methods of characterization of promoters using reporter genes; T-DNA mutagenesis; Non-*Agrobacterium* methods of genetic transformation – Gene gun and other methods; *In planta* transformation; Chloroplast transformation - vectors, gene integration through homologous recombination, Advantages; Characterization of transgenics through molecular and genetic means; Transgene silencing; Marker-free transgenics; Multigene engineering.

**Unit VI** [17]

**Applications of plant transgenic technology**

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



**Suggested readings:**

1. Plant Tissue Culture: Theory and Practice Bhojwani SS. & Razdan MK Elsevier
2. Plant Biotechnology: The Genetic Manipulation of Plants Slater A, Scott N & Fowler M Oxford University Press Inc.
3. Plants, Genes and Crop Biotechnology Chrispeels MJ & Sadava DE Jones and Barlett Publishers
4. Plant Cell Culture: Essential Methods Davey MR & Anthony P Wiley-Blackwell
5. Practical Applications of Plant Molecular Biology Henry RJ Chapman & Hall
6. Plant Biotechnology: An Introduction to Genetic Engineering Adrian Slater, Nigel W. Scott & Mark R. Fowler Oxford University Press
7. Biochemistry & Molecular Biology of Plants Bob Buchanan, Wilhelm Gruissem & Russell Jones John Wiley & Sons
8. Molecular Biotechnology Glick BR & Pasternak JJ ASM Press
9. Review and research articles

**Master's in Genetics  
Semester III**

**GENCC305: Experiments in Genetics –III**

**Marks: 200**

**Duration: 240 Hrs.**

**Course Objectives:**

The objective of this course is to give the students an exposure to the different techniques used in human genetics, mapping genes and plant biotechnology.

**Course Learning Outcomes:**

They will develop the ability of asking questions, designing experiments and carrying them out. They will have the skills of carrying out these techniques.

Microbial experiments

1. Isolation of lac constitutive mutants and their characterization (continued from Semester I)
2. Test the ability of WT and mutant strains of *S. cerevisiae* to utilize glycerol as the sole carbon source.
3. Test for the presence of mtDNA in the mutant *S. cerevisiae* strain.

Human genetics

4. Chromosome preparations from human lymphocyte cultures
  - i. G-banding of metaphase chromosomes
  - ii. Karyotyping with G- banded metaphase chromosomes
5. Chromosomal and interphase FISH of human chromosomes
6. DNA isolation from lymphocytes
  - i. Quantitative and qualitative analysis
  - ii. Genotyping with (a) Microsatellite markers and (b) SNPs
  - iii. Mutation screening by (a) PCR- RFLP and (b) PCR- sequencing

Mapping genes

7. Linkage analysis with microsatellite markers and LOD score estimations
8. Diversity analysis using program NTSYS
9. Construction of linkage map using program JoinMap4
10. Demonstration of program used for QTL mapping
11. Field trip to plant breeding station

Experiments on plant transformation

12. Shoot tip and nodal bud culture for multiplication of tobacco
13. Plant regeneration in tobacco (organogenesis)
14. Induction of embryogenic callus and plant regeneration in rice

15. Induction of hairy roots in tobacco leaf explants by *Agrobacterium rhizogens*
16. *Agrobacterium*-mediated genetic transformation of tobacco using leaf disc method
17. Histochemical assay for GUS activity from the transformed tissue of tobacco
18. Isolation of genomic DNA (by CTAB method) from transformed and un-transformed tissue of tobacco
19. Determination of transgene integration in the tobacco transformants by PCR analysis

**Master's in Genetics  
Semester IV**

**GENCC401: DEVELOPMENTAL BIOLOGY AND IMMUNOLOGY**

**Marks: 100**

**Duration: 60 Hrs.**

**DEVELOPMENTAL BIOLOGY**

**Course Objective:**

The course envisages giving an insight into how developmental patterns arise using examples from different model systems and highlighting regulatory networks involved in these processes. The students are however expected to have studied the basic processes of development (animal and plant embryology). The emphasis would be on experiments done which led to various concepts.

**Course Learning Outcomes:**

**CO1:** Students will learn the basic mechanism of developmental processes

**CO2:** Developmental processes in various animal model systems will be taught in this course

**CO3:** Students will be able to appreciate the various techniques used in plant biology to study the cause and effect relationship during plant development processes

**Contents**

**Unit I** [8]

**Concepts of development**

Specification, induction, competence, determination and differentiation, morphogen gradients, pattern formation, cell fate and cell lineages, cell to cell communication.

**Unit II** [10]

**Strategies in animal development**

Fertilization in sea urchins and mammals; early developmental processes like cleavage, gastrulation and axis formation using examples of sea urchin, *C. elegans*, *D. melanogaster*, amphibians and mammals; Morphogenesis and organogenesis of cell aggregation and differentiation in *Dictyostelium discoideum* formation of vulva in *C. elegans* and development of the tetrapod limb; introduction to stem cells; regeneration.

**Unit III** [12]

**Developmental processes in plants**

Salient features, comparison between plant and animal development pattern; Understanding plant development through examples –regulation of transition to flowering, floral meristem and the ABC

model of flower development in Arabidopsis.

**Suggested readings:**

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

**IMMUNOLOGY**

**Course Objective:**

The course provides a comprehensive overview of basic immunology in a manner that is understandable for students from different backgrounds. Topics of clinical relevance, such as microbial immunity, allergy, autoimmunity, tumor immunology, congenital and acquired immunodeficiency, transplantation immunology, and immunotherapy will also be covered.

**Course Learning Outcomes:**

**CO1:** On completion of this unit, students will get familiar with all components of the immune system- their structure and function during immune response.

**CO2:** Students will learn of the importance of a balanced immune system by studying both depletion and excess of the immune action.

**CO3:** Immune products (such as antibody) have been a mainstay of diagnosis and therapy. Recent advancements in use of immune cells and molecules will be introduced to the students

**Contents:**

**Unit I** [12]

**Our immune system and its function**

Fundamental concepts in immunology; Immune cells and organs; Innate Immunity; Inflammation; Pattern recognition; Complements; Antigen presentation; T and B cell development and activation; Cytokines; Antibody structure and function; Molecular mechanisms of generating antibody diversity; Genetic organization of MHC-I and MHC-II molecules; Peptide loading and function of MHC; Generating immune response against virus, bacteria and other pathogens; Immune cell receptors; Collaborations between B and T cells.

**Unit II** [12]

**Disease and deficiencies associated with immunity**

Tolerance and autoimmunity, Immunological disorders; Hypersensitivity, Transplantation; Tumor immunology

### Unit III

[6]

#### Advancement in technology

Hybridoma technology and monoclonal antibodies, antibody engineering, Using dendritic cells for cancer therapy, Chimeric Antigen receptor therapy

#### 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 Janeway CA, 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

**Master's in Genetics**  
**Semester IV**  
**GENCC402: PROJECT WORK**

**Marks: 300**

**Duration: 360 Hrs.**

**Course Objective:**

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

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

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

**Master's in Genetics  
Semester IV**

**GENEC403: ADVANCES IN *DROSOPHILA* GENETICS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

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

**Course Learning Outcomes:**

- CO1:** To develop a comprehensive understanding about *Drosophila* as a prime model organism, strategies to design genetic crosses and available resources.
- CO2:** To become aware of the various mutagenesis techniques, strategies to characterize mutant lines and to generate transgenic lines.
- CO3:** To understand the genetics of gametogenesis, cellular signaling, axis formation in oocyte, cellular remodeling and differentiation during germ cell development.
- CO4:** To develop an inclusive concept about developmental program, body axis formation, cellular signaling, differentiation, specification, imaginal discs and organogenesis.
- CO5:** To cultivate perception about various features of somatic and germline stem cells, stem cell niches, cellular signaling involved maintenance of stemness, differentiation and application.
- CO6:** To equip the students with the information of various powerful classical and contemporary genetic tools and techniques for genetic, cellular and molecular analysis in *Drosophila*.
- CO7:** To develop an understanding about utilization of *Drosophila* as a model for human genetic disorders, drug screening, aging and behavioral studies, and to discuss some *Drosophila* based breakthrough research papers which shaped the modern biology.

**Contents:**

**Unit I**

[8]

***Drosophila* as a model organism**

Historical prospective, An overview - life cycle and advantages in genetic analysis, developmental studies and biomedical research. Nomenclature of gene mutations; balancer and marker chromosomes and associated common phenotypes, strategies to design genetic crosses, an overview of *Drosophila* specific online databases, stock centers and other resources.



**Unit II** [8]

**Mutagenesis and isolation of new variants**

Radiation and chemical mutagenesis; P-element and insertional mutagenesis; Mapping of new mutations by recombination, deletion, complementation mapping and molecular approaches. Generation of novel GFP line by Protein Trap Transposon. Screening of gene functions

**Generation of transgenic lines**

P-element based vectors; selection of suitable vector; Germ-line transformation, microinjection, transgenic screening and characterization.

**Unit III** [10]

**Axis specification and cellular signaling during oogenesis**

*Drosophila* female reproductive system, overview of oogenesis and stage identification, selection of potential oocyte, somatic and germ cell derivatives; Delta, JAK/STAT, Notch signaling and specification of A/P polar cells and axis determination, ring canals, transportation and localization of transcripts and protein in oocyte, Gurken signaling and axis determination, border cell migration, cytoplasmic dumping and oocyte maturation. Analysis of some female sterile mutant lines.

**Cellular remodeling and differentiation during spermatogenesis**

*Drosophila* male reproductive system, mitotic and meiotic cell divisions, spermatogonia, spermatocytes, cyst cell, mitochondrial remodeling, nebenkern, nuclear shaping, actin polymerization, sperm individualization.

**Unit IV** [12]

**Genetics of development**

Overview of embryogenesis, axis formation, fate map. Genetic hierarchy of development in *Drosophila*- egg polarity genes, establishment of morphogen gradient, gap genes, pair rule genes, specification of stripes, regulation of pair-rule gene expression, segment polarity genes, establishment of segment polarity, homeotic genes and mutations, antennapedia/bithorax complex and specification of body organs. Larval stages and tissue types, imaginal discs - development and differentiation, axis determination in imaginal discs, regeneration and trans-differentiation, adult morphology and internal organs.

**Unit V** [6]

**Stem cells and their maintenance**

Somatic and germ line stem cells. Components and functions of stem cell niches. Stemness, Various cellular signaling (i.e. Delta-Notch, JAK-STAT etc.) and maintenance of stemness. Differentiation of stem cell and maintenance of organ homeostasis. Therapeutic usages of stem cells.

### ***Drosophila*- a model system to study immune responses**

Induction of immune response, antimicrobial defense, Toll and Immunodeficiency (IMD) signaling pathways.

#### **Unit VI**

[8]

#### **Tools for genetic, cellular and molecular analysis**

Genetic tools for studies on gene expression; Generation and analysis of FLP/FRT mediated somatic clones. Generation and analysis of ovoD mediated germ-line clones; Conditional and/or targeted over-expression/ablation of genes/transcripts (e.g. UAS/GAL4/GAL80 system); RNAi-based screening of gene functions. *Drosophila* genome editing by CRISPR-Cas9.

#### **Unit VII**

[8]

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

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

#### **Suggested readings:**

- |  |                     |                |
|--|---------------------|----------------|
| 1. Developmental Biology   | Gilbert SF          | Sinauer Press  |
| 2. Development of <i>Drosophila melanogaster</i> (Vol. I & II)           | Bates & Arias       | CSHL Press     |
| 3. <i>Drosophila</i> Guide   | Demerec & Kaufmann  | Carnegie Press |
| 4. <i>D. melanogaster</i> : Practical Uses in Cell and Molecular Biology | Goldstein & Fyrberg | Academic Press |
| 5. The making of a fly: The genetics of animal design                    | Lawrence            | Blackwell      |
| 6. <i>Drosophila</i> : Methods and Protocols                             | Dahmann C           | Humana Press   |
| 7. Fly Pushing: The Theory and Practice of <i>Drosophila</i> Genetics    | Greenspan RJ        | CSHL Press     |
| 8. <i>Drosophila</i> : A Practical Approach                              | Roberts DB          | CSHL Press     |
| 9. Compiled reviews and research papers                                  |                     |                |

**Master's in Genetics**

**Semester IV**

**GENEC404: BIOLOGY OF *DICTYOSTELLIUM***

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

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

**Course Learning Outcomes:**

**CO1:** To introduce the organism and its family, past findings, about its genome and present techniques,

**CO2:** To give an account on *D. discoideum* cellular structure, growth-specific processes and regulation operating prior to nutrient starvation,

**CO3:** To develop the understanding of how *D. discoideum* respond to nutrient starvation, processes and events in development, role of important molecules and signaling pathways during development,

**CO4:** To emphasize the use of *D. discoideum* as an emerging model in studies to understand various processes and human diseases,

**Contents:**

**Unit I**

[8]

**Brief introduction**

An overview; *Dictyostelium discoideum* and its relatives

**History of research on *D. discoideum***

Classical experiments of Kenneth Raper; Chemotaxis and aggregation; Molecular techniques

**Evolution and Genome**

**Unit II**

[12]

**Cellular organization and Dynamics**

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

**Initiation of Development**

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

### Unit III

[36]

#### Chemotaxis and Aggregation

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

#### Cell adhesion and Recognition

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

#### Signal transduction

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

#### Cell differentiation and Pattern formation

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

#### Coordinated cell movement and Morphogenesis

### Unit IV

[4]

#### *Dictyostelium* in biology and medicine

#### Suggested Readings

1. Dictyostelium, Evolution, Cell Biology, and the Development of Multicellularity  
Richard H Kessin  
Cambridge University Press
2. Dictyostelium-A model system for cell and developmental biology  
Yasuo Maeda, Kei Inouye and Ikuo Takeuchi (Eds)  
Universal Academic Press, Inc. Tokyo Japan
3. *Dictyostelium discoideum*: molecular approaches to cell biology. *Volume 28 of Methods in Cell Biology*  
James A Spudich  
Academic Press
4. Original Research papers

**Master's in Genetics  
Semester IV**

**GENEC405: CANCER BIOLOGY AND GENETICS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

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

**Course Learning Outcome:**

**CO1:** The students will have an enhanced understanding of epidemiology and incidence of cancer in India and the world. They will learn of pathological changes that a normal cell and tissue undergoes when transformed to a tumor, and get familiar with nomenclature and basic diagnosis.

**CO2:** Students will learn about mechanisms of oncogenesis in a historical perspective of seminal discoveries of cancer biology in a timeline.

**CO3:** Molecular and cellular changes while the tumor is progressing will enhance the student's knowledge on basic biology and therapeutic potential of molecular carcinogenesis.

**CO4:** In this emerging and advanced area of cancer immunotherapy, the students will learnt to correlate their basic knowledge in immunology with that of cancer and how it has led to therapeutic intervention.

**CO5:** This portion will familiarize the students with standard therapy in practice. Further with examples from the molecular pathways of cancer progression studied in the previous unit, they will learn about progression of that knowledge from bench to bedside.

**Contents:**

**Unit I**

[10]

**Epidemiology and molecular pathology of cancer**

Biology of a cancer cell; Pathology of tumor/cancer tissues; Classification of tumor/cancers; Diagnostic tools for cancer detection; Molecular pathology; Molecular and diagnostic marker

**Unit II**

[16]

**Mechanistic basis of oncogenesis**

Hallmarks of cellular transformation; Genetic basis of oncogenesis; Influence of environment and lifestyle changes; Chromosomal rearrangements; Mutations; Aneuploidy; Multistage

tumorigenesis; Viral theory of carcinogenesis; Tumor suppressors, Oncogenes, DNA repair defects; Knudson's two-hit hypothesis; Mutator hypothesis; Loss of heterozygosity analysis, allelotyping, microsatellite instability

**Unit III** [16]

**Biology of tumor progression**

Signalling pathways of cancer; Cancer progression; Metastasis; Angiogenesis; Epithelial to mesenchymal transformation; Tumor microenvironment; Oncogene addiction; Current papers on advances in the field.

**Unit IV** [8]

**Tumor immunology**

Role of immune system in preventing tumor growth; Escape mechanisms against immune surveillance; Tumor antigens; Therapy based on the immune response.

**Unit V** [14]

**Advances in cancer therapy**

Molecular diagnostics, imaging; Types of cancer therapy in routine use; Overview of different chemotherapy used as standard-of-care; Molecular basis of targeted therapy; Examples of success stories in cancer treatment and their evolution based on molecular and technological advances.

**Suggested readings:**

- |    |                                   |                             |                              |
|----|-----------------------------------|-----------------------------|------------------------------|
| 1. | The Biology of Cancer             | Robert A. Weinberg (Ed.)    | Garland Sciences             |
| 2. | The Molecular Biology of Cancer   | Pelengaris S, Khan M (Eds.) | Blackwell Publishing, Oxford |
| 3. | The Genetic Basis of Human Cancer | Vogelstein & Kinzler        | McGraw-Hill                  |
| 4. | Review and research articles      |                             |                              |

**Master's in Genetics  
Semester IV**

**GENEC406: GENETIC COUNSELLING**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objectives:**

This era in medical genetics and molecular diagnostics is the most exciting in medical practice and research due to unprecedented technical advances. At the same time it has also become very challenging. In view of the ever growing knowledge on genetics of diseases, tremendous scope to develop suitable tests for prediction and prevention of diseases, dissemination of scientific advances to the common man, through the internet and a range of freely available websites, genetic counseling by trained professionals is becoming increasingly important. Knowledge explosion with free accessibility with little understanding of the deeper principles for application is a major social concern. This paper is aimed at motivating the students of genetics to take up genetic counseling as a career option, which will generate the much needed manpower in this field not only in India but globally. A didactic approach and problem based tutorial exercises which seem to be the most effective method of introducing and training students in this branch of applied genetics would be followed.

**Course Learning Outcomes:**

**CO1:** Gain knowledge to identify the group of disorders which have a genetic basis and enable risk assessment based on the inheritance pattern

**CO2:** Awareness of the different tools and techniques available for the different diseases

**CO3:** Knowledge on the range of possible tests for different diseases and at different stages of life; understanding risk and benefit; and therapeutic possibilities for different disorders

**CO4:** Gaining skill sets to become a good counselor

**CO5:** Awareness of the overall implications of the results of genetic testing

**Contents:**

**Unit I**

[18]

**Principles of human genetics**

Modes of inheritance of common and rare diseases; autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive and complex disease conditions; exceptions to Mendelism; mitochondrial disorders; pedigree analysis

## Unit II

[16]

### Tools and techniques in molecular medicine

Literature of human and medical genetics; Cytogenetics; Biochemical genetics; Molecular diagnosis and genomics; Dysmorphology, teratology, inherited congenital and adult onset diseases; Use of databases relevant to these areas; disease risk estimation

## Unit III

[12]

### Genetic testing

Prenatal/neonatal/pediatric/adult diagnosis of genetic disorders; reproductive genetics, cancer genetics; a few case studies; Risks and benefits; Informed consent; Right of choice; Dilemmas faced by counselors; Pre-prescription testing

### Methods of therapy

Drug (recombinant proteins); Diet; Gene (viral vectors, delivery methods, efficacy); Some examples (Thalassemia, Phenylketonuria, Cystic fibrosis, DMD, etc)

## Unit IV

[6]

### Development of skills

Communication and counseling skills; facilitating application of theory to practice; handling psychological issues; non-directive counseling

## Unit V

[8]

### Ethical, legal social and cultural issues

Ethical principles; informed consent; human rights; genetic law; impact of illness on individual/family/society; insurance, employment and discrimination issues

### Suggested readings:

- |    |   |  |   |
|----|---|--|---|
| 1. | Practical genetic counselling   | Harper, Peter S                        | London: Hodder Arnold,                  |
| 2. | Genetics for the health sciences : a handbook for clinical healthcare | Skirton, Heather; Patch, Christine     | Bloxham, Oxfordshire: Scion             |
| 3. | Introduction to risk calculation in genetic counseling                | Young, Ian D.                          | New York, N.Y.: Oxford University Press |
| 4  | New clinical genetics   | Read, Andrew P.; Donnai, Dian          | Oxfordshire, UK: Scion,                 |
| 5. | Principles of biomedical ethics                                       | Beauchamp, Tom L.; Childress, James F. | New York: Oxford University Press,      |



**Masters in Genetics**

**Semester IV**

**GENEC407: GENETICS OF PLANT-MICROBE INTERACTION**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

Pathogenic microbes are a global threat not only to human health but also to food production and quality. With the ever increasing demand to improve agricultural yields to keep up with the global food demand this area of host – microbe interaction is becoming more and more important for sustainable agriculture. This advanced course is designed to provide the students insights into the genetic and molecular principles underlying immunity in plants and microbial pathogenesis. The interactions between microbes and plants provide fascinating examples of biological communication. The course design explores the molecular intricacies underlying the host-pathogen relationships, the virulence factors that promote colonization and survival of infecting microorganisms and virulence attributes that damage the host.

**Course Learning Outcomes:**

- CO1:** Gain an understanding of the nature and importance of immunity mechanisms in plant biology
- CO2:** Student will become familiarize with the latest methods used to dissect the host –microbe interaction at the genetic, cellular and molecular level and various model systems used.
- CO3:** Gain an understanding of the pathogenic lifestyles of necrotrophic and biotrophic plant pathogens and the molecular aspects of the virulence strategies used by the pathogen6.
- CO4:** Student will be able to comprehend the defense mechanisms employed by the plants against these pathogens and how the two co-evolve.
- CO5:** Use knowledge of molecular interactions to understand the basis for current disease

**Contents:**

**Unit I**

[4]

**Introduction**

A historical perspective, significance of plant health, current challenges to sustainable crop production and introduction to central concepts underlying host-microbe interactions, molecular Koch's Postulates

**Unit II** [4]

**Research tools used to study host- microbe interaction**

Genomic tools, molecular and cellular genetics, imaging for bacteria, fungi and oomycetes.

**Unit III** [6]

**Model pathosystems**

Arabidopsis/ Nicotiana- *Pseudomonas*, - potato -*Phytophthora*.

**Unit IV** [8]

**Microbial pathogenesis**

Various strategies of pathogenicity, symbiosis, commensalisms and mutualism; Studying the infection processes and specificity of pathogens and their host range, Disease cycle and epidemics.

**Unit V** [16]

**Molecular genetic basis of pathogenicity**

Virulence factors, Gene for gene Model, molecular Koch's Postulates; Repertoire of effectors and their actions in pathogenesis; generation of variability.

**Unit VI** [16]

**Molecular and cellular basis of plant defence**

Non-host resistance, Plant innate immunity, Pre-formed inhibitors of pathogen invasion, Types of plant resistance – vertical and horizontal, R genes (quantitative and monogenic resistance); molecular mechanisms underlying basal and induced defense responses and systemic acquired resistance.

**Unit VII** [6]

**Disease resistance in agricultural contexts**

Translational research advances and potentials: Chemical control, Biocontrol, Biotechnological approaches.

**Suggested readings:**

- |   |               |                       |
|---|---------------|-----------------------|
| 1. Plant Pathology  | Agrios GN     | Academic Press        |
| 2. Molecular Plant pathology  | Dickinson M   | BIOS Scientific Press |
| 3. Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions | Jeng-Sheng HT | Kluwer Academic Publ. |
| 4. Reviews and research paper   |               |                       |

**Master's in Genetics**  
**Semester IV**

**GENEC408: NON-CODING RNA BIOLOGY, GENE SILENCING AND APPLICATIONS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

The goal of this course is to provide the in-depth knowledge about diversity of RNA world and the functional importance of various non-coding RNAs (ncRNAs) like siRNAs and miRNAs in the regulation of a wide range of biological processes, including defense and the regulation of chromatin structure and gene expression. This course also provides the use of this elegant and revolutionary reverse genetics approach in the elucidation of physiological function of genes and also for various potential applications with regard to developing new drugs and therapeutics for human diseases as well as the improvement of crop yield and quality.

**Course Learning Outcomes:**

- CO1:** Acquaint with the functional importance of various nc-RNAs, and RNA silencing mechanism and its components.
- CO2:** Gaining knowledge about the cellular functions of siRNAs and miRNAs and their vectors for gene silencing and its analysis.
- CO3:** Understanding the concept of miRNA interference (miRNAi), and the expression of miRNAs and their use as therapeutic targets for human disease control using mimic and anti-miR technologies.
- CO4:** Learning various genome editing tools like CRISPR-Cas9 system for genome engineering in various organisms.
- CO5:** The utility of RNAi in genome wide genetic screens for functional genomics studies in different systems.
- CO6:** To become aware of various potential applications of RNAi and miRNAi therapy for human diseases and also for crop improvement.

**Contents:**

**Unit I**

**[10]**

**Non-coding RNA biology**

Biogenesis and function of different types ncRNAs - rRNAs, tRNAs, snRNAs, snoRNAs, spliceosomal snRNAs, miRNAs, piRNAs, long ncRNAs and many others. Ribozymes – Catalytic RNA molecules. Discovery of RNA interference; Discovery and overview, Post-transcriptional gene silencing - Co-suppression, Quelling and RNAi. Mechanisms of RNAi; Components of RNAi pathways (Drosha, Dicer, Argonaute and RdRP) and their evolutionary conservation and role in gene silencing, Molecular basis of RNAi; siRNA- and miRNA- mediated gene silencing (Dicing and Slicing), RNAi in model systems – *C. elegans*, *Drosophila* and others.

**Unit II** [10]

**Cellular functions of siRNAs and miRNAs:**

Role in chromatin remodeling, control of transposon genetic elements and gene expression, dosage compensation, genomic imprinting, defense against viruses in mammals and plants; RNAi suppressors. siRNA, shRNA and amiRNA vectors and their *invitro* and *invivo* delivery in different systems; siRNA modifications, O'methyl, siHybrids, Use of nano-particles in siRNA target delivery; Off-target effects of siRNAs; Detection and analysis of sRNAs (siRNAs, miRNAs and amiRNAs) - RNAi microarrays, Stem-loop PCR, qPCR, Northern hybridization.

**Unit III** [12]

**miRNA interference technologies**

miRNAs targeting and targeting miRNAs – miRNA expression, mutation, polymorphism; miRNAs and human disease, miRNAs as therapeutic targets, miRNA interference (miRNAi) – A new concept; miRNAs as a regulator of cellular function; One-drug and Multiple-target; miRNA seed family; miRNA targeting technologies and Targeting miRNA technologies – miRNA mimic, transgene, Anti-miR (Antagomir) and knockout technologies.

**Unit IV** [8]

**Genome editing tools**

CRISPR locus in bacteria, Brief history, Mechanism of CRISPR pathway, CRISPR-Cas9 system for genome engineering in mammals, plants and other organisms; Zinc finger nuclease- based engineering; transcription activator-like effector- based nucleases(TALEN) in genome engineering. Synthetic RNA biology and engineering biological systems.

**Unit V** [10]

**Large-scale genetic analysis using RNAi**

Genome-wide RNAi screens in *C. elegans*, *Drosophila*, mammalian cell lines and other systems; siRNA and shRNA libraries; Virus induced gene silencing (VIGS) and its uses functional genomics studies in plants. RNomics; RNA informatics - computational tools for miRNAs discovery and their targets, design of siRNA, miRNA and artificial miRNA; high-throughput small RNA profiling - Next generation sequencing.

**Unit VI** [10]

**Applications of RNAi in humans, animals and plants:**

RNAi vectors and generation of transgenic animals and plants; Analysis of expression of dsRNA/siRNA molecules and gene silencing; Use of RNAi in the prevention of diseases in animal models; RNAi and miRNAi therapy for human diseases, Antisense RNAs, Clinical trials; RNAi and artificial miRNAs in crop protection and improvement; Future prospects of RNAi in

biology, medicine and agriculture.

**Suggested readings:**

- |    |   |                                   |                               |
|----|---|-----------------------------------|-------------------------------|
| 1. | The RNA World   | Gesteland <i>et al.</i><br>(Eds.) | CSHL Press                    |
| 2. | RNA Interference Technology:<br>From Basic Science to Drug<br>Development | Fire A <i>et al.</i> (Eds.)       | Cambridge<br>University Press |
| 3. | RNAi: A Guide to Gene<br>Silencing  | Gregory J &<br>Hannon (Eds.)      | CSHL Press                    |
| 4. | RNA Interference in Practice  | Ute Schepers (Ed.)                | Wiley-VCH GmbH<br>& Co. KGaA  |
| 5. | RNA Biology – An Introduction   | Gunter Meister                    | Wiley-VCH Verlag<br>CRC Press |
| 6. | Gene Silencing  | M.A. Matzke and<br>A.J.M. Matzke  | Springer                      |
| 7. | Review and research articles  |                                   |                               |

**Master's in Genetics**  
**Semester IV**  
**GENEC409: YEAST MOLECULAR GENETICS**

**Marks: 100**

**Duration: 60 Hrs.**

**Course Objective:**

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

**Course Learning Outcomes:**

**CO1:** Introduction to genome wide analysis experiments and synthetic biology.

**CO2:** In-depth understanding of the regulation of the powerhouse of the cell, its creation, regulation, motility and copy number.

**CO3:** Yeast as model for understanding cellular longevity and gene regulation upon nutrient changes.

**CO4:** Understanding the mechanism of non-mendelian inheritance and its consequence on cellular function.

**CO5:** Introduction to pathogenic yeast, its similarities and differences with its non-pathogenic cousins.

**Contents:**

**Unit I** [8]

**The yeast genome**

Life with 6000 genes; Post-genomic era - genome-wide microarrays, proteomics, genome-wide protein localization; Synthetic gene array analysis, SC2.0

**Unit II** [14]

**Mitochondrial Physiology**

Mitochondrial dynamics; Mitochondrial fusion and fission; Mitochondrial control by nuclear genome; Mitochondrial retrograde signaling; Mitochondrial gene expression; links with nuclear gene expression

**Unit III** [22]

**Life span**

Chronological and Replicative life span; calorie restriction; signaling and alteration in gene expression

**Transcription and Translational Control by nutrition**

Amino acid starvation; TOR signaling; transcriptional control by GCN4

**Unit IV** [8]

**Prions in yeast**

Inheritance pattern, prion propagation, *de novo* prion formation, prion structure and biological effects

**Unit V** [8]

**Pathogenic yeasts**

Diseases caused; Introduction to *Candida albicans*; Distinctions between *S. cerevisiae* and *C. albicans* mating types, mitochondrial physiology and carbon utilization

**Suggested Readings:**

1. Guide to Yeast Genetics and Molecular Biology, Methods Enzymol. Vol. 194 Guthrie C & Fink Elsevier Academic Press GR(Eds.)
2. Getting started with yeast, Methods Enzymol. Vol. 350, pp. 3-41 (2002) Sherman F
3. Yeast Research: A Historical Overview James A. Barnett & Linda Barnett A S M Press