M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for academic year 2022 onwards)

M.Sc. GENETICS I YEAR
SEMESTER – I

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G101T	Principles of Inheritance	3	4	30	70	100
2.	G102T	Cell Biology & Cytogenetics	3	4	30	70	100
3.	G103T	Fundamentals of Biochemistry	3	4	30	70	100
4.	G104T	Biostatistics and Population Genetics	3	4	30	70	100
PRACTICALS							
1.	G151P	Principles of Inheritance	2	4			50
2.	G152P	Cell Biology & Cytogenetics	2	4			50
3.	G153P	Fundamentals of Biochemistry	2	4			50
4.	G154P	Biostatistics	2	4			50
		Total	**20**				**600**

M.Sc. GENETICS-I YEAR
SEMESTER- I
THEORY PAPER- I
G101T: PRINCIPLES OF INHERITANCE

1. Course Objectives (C. Obj.)

a. To understand the molecular basis of Mendelian Inheritance in plants, animals and man.
b. To acquaint the need of various model organisms used in genetic analysis.
c. To analyze the linkage and mapping of genes in eukaryotic and prokaryotic systems.

2. Course Outcomes (C.O)

a. Comprehend and apply the Mendelian inheritance in humans, plants and animals.
b. Gain knowledge on the use and handling of model organisms in research studies.
c. Understand how to solve and analyze the linkage analysis of genes in eukaryotic and prokaryotic systems.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**PATTERNS OF INHERITANCE**	
1.1	**Mendel's Laws of Inheritance** a) Law of segregation - Mendel's experiments and reasons for success, monohybrid cross, reciprocal cross, Law of dominance, test cross, backcross b) Law of Independent Assortment – dihybrid cross, test cross, back cross. c) Pedigree analysis – autosomal pedigree, sex-linked pedigree	3
1.2	**Extensions and deviations to Mendelian Inheritance** a) Allelic Interactions- incomplete dominance, co-dominance, over-dominance, lethal factor, multiple alleles (eye colour in drosophila, ABO blood group in man, coat colour in rabbit, self-incompatibility in plants), pleiotropism b) Non-allelic Interactions - supplementary gene interaction, complimentary gene interaction, inhibitory gene interaction, duplicate gene interaction, polymeric gene interaction, masking gene interaction c) Complex loci -R locus in maize, Rh blood group system	3
1.3	**Genes and Environment** a) Penetrance and Expressivity- mechanisms explaining incomplete penetrance and differences in expressivity b) Polygenic Inheritance – characteristics, plants (kernel colour in wheat, length of corolla in tobacco), humans (skin colour, height, eye colour), analysis of polygenic traits c) Norm of Reaction – eye size in drosophila, norm of reaction to elevation in Achillea, developmental noise.	3

1.4	**Sex-linked inheritance and sex determination** a) Sex-linked Inheritance in Drosophila – X-linked white eyes in Drosophila b) Sex-linked Inheritance in Man – X-linked inheritance (colour blindness, haemophilia), Y-linked traits, XY-linked inheritance, sex-influenced traits, sex-limited traits. Dosage compensation c) Sex Determination – chromosomal sex-determining systems, genic-sex determining systems, environmental sex determination, sex determination in drosophila and man.	2
1.5	**Non-Mendelian Inheritance** a) Maternal inheritance- shell coiling, eye pigmentation in flour moth b) Uniparental Inheritance - streptomycin sensitivity in Chlamydomonas c) Cytoplasmic inheritance - chloroplast inheritance in variegated fouro clock plant, mitochondrial inheritance (petite in yeast, poky strain in Neurospora, man) Male sterility in plants, iojap in maize, endosymbionts (sigma virus, spirochaetes, kappa particles, milk factors)	4

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**PROKARYTOIC AND EUKARYOTIC MODEL SYSTEMS IN GENETIC ANALYSIS**	
2.1	**Bacteriophage and E. *Coli*** a) Structure and Life Cycle of Bacteriophage – T4 bacteriophage, morphology, composition, model genetic system, applications b) E. *coli* as Model Organism – genetic manipulation, applications c) E. *coli* Genome - features and resources	3
2.2	**Yeast** a) Life cycle - mitotic cell cycle, mating and sporulation b) Importance – model organism in genetics, cell and molecular biology, applications. c) Genome - features and resources	3
2.3	**Caenorhabditis elegans** a) Life cycle - anatomy, stages b) Importance – model organism in genetics and biology, applications c) Caenorhabditis *elegans* Genome - features and resources	3
2.4	**Drosophila** a) Life cycle morphology, stages. b) Importance – model system, genetic resources, applications c) Drosophila genome - features and resources	3
2.5	**Arabidopsis** a) Life cycle – growth stages. b) Importance of Arabidopsis –reasons for adoption, as model for plant molecular genetic analysis, applications c) Arabidopsis Genome - Features and Genome Resources	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**LINKAGE, GENETIC MAPPING AND CONCEPT OF GENE**	
3.1	**Discovery of Linkage** a) Early evidence for linkage and genetic recombination Chromosome theory of inheritance, Morgan's experimental crosses of white eye and miniature wings, Bateson and Punnett experiment on linkage. b) Cytological proof of crossing over – Stern's experiment in Drosophila, Creighton and McClintock evidence of crossing over in maize, factors affecting crossing over, theories of crossing over, types of crossing over c) Detecting linkage through test cross – linkage groups	2
3.2	**Gene mapping in Eukaryotes** a) Gene mapping with Two-point test crosses – types of linkage, recombination frequency, significance of linkage, limitations of two-point test cross. b) Genetic mapping with Three-point test crosses - distance and gene order, interference, coefficient of coincidence. c) Constructing genetic linkage maps in humans - grandfather method, autosomal linkage.	3
3.3	**Tetrad analysis and mitotic crossing over** a) Tetrad analysis in Neurospora – first and second division segregation, gene order, Analysis of ordered tetrads b) Tetrad analysis in yeast – analysis of unordered tetrads c) Mitotic crossing over – Aspergillus *nidulans*, twin spots in Drosophila.	4
3.4	**Gene Mapping in Prokaryotes** a) Conjugation – F factor, interrupted mating, mapping by conjugation. b) Transformation – transformation mapping. c) Transduction – generalized transduction, specialized transduction, mapping with transduction.	3
3.5	**Fine Structure of Gene and Concept of Gene** a) Beadle and Tatum's One Gene One Enzyme Concept – one gene-one polypeptide hypothesis. b) rII locus in T4 phage - Benzer's experiments, Oliver experiment on lozenge locus in drosophila, complementation test. c) Modern Concept of Gene – classical, neoclassical and modern concepts.	3

PRACTICALS

G151P: PRINCIPLES OF INHERITANCE

S. No.	Topic to be covered
UNIT-1	
1	Using Chi-square test on Mendelian ratios and gene interaction ratios
2	Pedigree analysis
3	Segregation in human pedigrees
4	Life cycle of Drosophila
5	Identification of mutants in Drosophila
6	Segregation analysis in Drosophila
7	Life cycle of maize
8	Segregation analysis in maize cobs
UNIT-2	
9	Genetics of Blood Groups - ABO –typing, Rh (D) typing and ABHSecretor status
10	Sex determination in maize
11	Solving Problems on Gene Mapping– Three-point Test Crosses
12	Solving Problems on Tetrad Analysis
13	Growth of Neurospora and analysis of cross for ascospore observations.
14	Conjugation in bacteria
15	Transformation of Escherichia coli by plasmids.

BOOKS RECOMMENDED

1. An Introduction to Genetic Analysis, 7th edition Anthony JF Griffiths, Jeffrey H Miller, David T Suzuki, Richard C Lewontin, and William M Gelbart. New York: W. H. Freeman; 2000. ISBN-10: 0-7167-3520-2.
2. Genetics: A Conceptual Approach by Benjamin A Pierce (W.H. Freeman & Co. Ltd2014 ISBN-13:9781464109461.
3. Introduction to Genetics: A Molecular Approach T A Brown Edition:1st Garland Science Taylor & Francis Group ISBN: 9780815365099
4. Concepts of Genetics by William S. Klug, Michael R. Cummings, Charlotte A. Spencer 2005 Benjamin-Cummings Publishing Company ISBN 0131918338 (ISBN13: 9780131918337)
5. Genetic Analysis: An Integrated Approach by Mark Frederick Sanders, John L. Bowman2014 edition ISBN: 0321948904/ ISBN-13: 9780321948908.
6. Drosophila: A Laboratory Hand book by Michael Ashburner Cold Spring Harbor Laboratory Press, U.S.; 2nd ed. edition ISBN-13:978-1936113699.
7. Theory and Problems of Genetics (Schaum's Outline Series) by William Stansfield McGraw-HillBook Company.

M.Sc. GENETICS- I YEAR
SEMESTER- I
THEORY PAPER- II
G102T: CELL BIOLOGY AND CYTOGENETICS

1. Course Objectives (C. Obj.)

a. To give an insight about the organelles and cytoskeleton of the cell, and cell death processes like apoptosis.
b. To provide an in-depth knowledge about the cell cycle, cell division and check points.
c. To understand structure and components of chromosome, hierarchical organization of chromatin and their modifications, structural and numerical chromosomal abnormalities in plants and animals.

2. Course Outcomes (C.O)

a. Comprehension of the basic structure and functions of the organelles and cytoskeleton, and further understand cell death mechanisms.
b. Gain conceptual knowledge on the phases of the cell cycle, check points, mitosis & meiosis in detail.
c. Gain an insight about chromatin organization so as to apply the knowledge for understanding epigenetics and to understand the concept of chromosomal breakage, structural and numerical abnormalities in plants and animal chromosome.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**EUKARYOTIC CELL & CELL DEATH**	
1.1	**Structure and function of** a) Endoplasmic reticulum b) Golgi complex & Secretory pathway c) Cell wall & plasmodesmata	2
1.2	**Structure and function of** a) Mitochondria b) Chloroplast c) Peroxisomes & Lysosomes (autophagy)	3
1.3	**Structure and function of Cytoskeleton** a) Microtubules b) Intermediate filaments c) Microfilaments	3
1.4	**Extracellular matrix and cell matrix interactions** a) Extracellular matrix structural proteins, matrix Polysaccharides and adhesion proteins. b) Cell-cell junctions (tight junctions, gap junctions, adherent junctions & desmosomes). c) Cell-Matrix junctions (hemidesmosomes & focaladhesions)	4

1.5	**Programmed Cell death** a) Morphological events of apoptosis and Significance b) Extrinsic pathway of apoptosis c) Intrinsic pathways of apoptosis	3

Unit Number	Topics to be covered	No. of lectures
Unit 2	**CELL CYCLE & CELL DIVISION**	
2.1	**Cell cycle** a) Phases of cell cycle - G1(Restriction point), S, G2, M and G0 (Quiescence phase). b) Cyclins & CDK's: Families of cyclins & CDK's (G1, S, G2 & M phase). c) Mechanisms of CDK's regulation (Association with cyclin, activating phosphorylation, inhibitory phosphorylation & CDK's inhibitors, APC/C & SCF).	4
2.2	**Check points in cell cycle** a) G1-S check point (E2F & p53), b) G2-M check point (MPF, ATM &ATR) c) Mitosis check point (Spindle assembly- APC)	3
2.3	**Cell Division** a) Mitosis-Overview of stages, Mitotic apparatus, distribution of microtubule organizing centers, sister chromatid separation (cohesions & condensins) and cytokinesis. b) Meiosis: Overview of Meiosis I & II – Stages (synaptonemal complex & chiasmata). c) Significance of mitosis and meiosis.	3
2.4	**Chromosome Morphology** a) Chromosome structure & Classification (chromatids, centromere (primary, secondary constriction/Nucleolar organizer & kinetochore), telomere and satellite). b) Specialised Chromosomes (Polytene and lampbrush chromosomes). c) Cytogenetic mapping and deletion mapping.	3
2.5	**Dosage compensation & Chromosome Segregation** a) X-chromosome Inactivation (XIST, X-inactivation centre) & Dosage compensation (X-linked genes in Drosophila. melanogaster & Mammals). b) Mechanisms of non-disjunction: Non-disjunction in Meiotic I and II, Mitotic non-disjunction. c) Mechanisms of anaphase lag.	2

Unit Number	Topics to be covered	No. of lectures
Unit 3	**CHROMATIN ORGANIZATION AND CHROMOSOMALABERRATIONS**	
3.1	**Components of chromatin** a) Nucleic acids b) Histones & non-Histones c) Euchromatin & Heterochromatin	2
3.2	**Chromatin organization** a) Nucleosome Structure & organization (Histone assembly and coreparticle location of H1) b) Higher order structure (solenoids, loops and scaffolds) c) Nucleosome phasing (active and inactive chromatin)	4
3.3	**Chromatin remodeling** a) Histone Modifications (Acetylation, Methylation (lysine & arginine) phosphorylation, ubiquitinylation & SUMOylation, ADP ribosylation and deamination) b) Chromatin remodeling complexes c) Chromatin function in Evolution	3
3.4	**Chromosomal anomalies** a) Structural chromosomal abnormalities (Origin of breaks and gaps, ring chromosomes, Isochromosomes, centric fusion, centric fission, breakage fusion bridge cycle. Deletions, Duplications, Inversions, Translocations). b) Numerical chromosomal abnormalities (Aneuploidy, Polyploidy) c) Chromosome instability (Ataxia telangiectasia, Fanconi anemia and Bloom syndrome, Xeroderma pigmentosa) & Sister chromatid exchanges.	3
3.5	**Cytogenetic Techniques** a) Chromosome Banding Techniques (G, Q, T, R, etc), Insitu hybridization b) Karyotyping & clinical significance c) Insitu hybridization techniques: FISH, SKY	3

PRACTICALS
G152P: CELL BIOLOGY AND CYTOGENETICS

S.No.	Topics to be covered
UNIT-1	
1.	Light microscope-Bright-Field Microscope, Dark Field Microscope& Phase contrast microscope
2.	Fluorescence & Confocal microscope
3.	Transmission Electron Microscopy (TEM)/Scanning Electron Microscopy (SEM)
4.	Observation of eukaryotic cells- epidermis of onion fleshy leaves
5.	Mitosis in somatic tissues of plants (Onion root tips) / animals (Mouse)
6.	Meiosis in germinal tissues of plants (Maize/ Lilly) / animals (Grasshopper Testes)
7.	Barr Body identification

UNIT-II	
8.	Preparation of Polytene Chromosome
9.	Induction of polyploidy
10.	Lymphocyte culturing
11.	Karyotype analysis
12.	G banding
13.	Sister chromatid exchanges
14.	Flouroscence *insitu* Hybridisation
15.	Spectral Karyotyping

BOOKS RECOMMENDED

1. The Cell: A Molecular Approach by Goeffrey Cooper and Robert Hausmann
2. Human Chromosomes: Orlando J. Miller & Eeva Therman 4th edition
3. Chromosome Techniques (Third Edition) Theory and Practice Author(s): Arun Kumar Sharma and Archana Sharma
4. Molecular biology of the cell (6^{th} edition)- Bruce Alberts
5. Cell and Molecular biology (eighth edition): De Robertis.

M.Sc. GENETICS I YEAR
SEMESTER- I
THEORY PAPER- III
G103T: FUNDAMENTALS OF BIOCHEMISTRY

1. Course Objectives (C. Obj.)

a. To learn the basics of chemistry related to biomolecular functions
b. Comprehend carbohydrate classification and metabolism.
c. To learn lipid, amino acid and nucleotide metabolism and signaling processes.

2. Course Outcomes (C. O)

a. Understanding the basics of biochemical processes.
b. Comprehension of central carbon metabolism.
c. Acquaintance with classification and metabolism of non-carbohydrate biomolecules and knowledge regarding the cell signaling processes and their importance.

Unit Number	Topics to be covered	No. of lectures
Unit 1	**BIOLOGICAL MACROMOLECULES, PROTEINS AND ENZYMES**	
1.1	**Carbohydrates** a) Aldoses and ketoses, classification of monosaccharides b) Disaccharides and Polysaccharides c) Glycoconjugates- Proteoglycans, Glycoproteins & Glycolipids	2
1.2	**Amino acids and proteins** a) Classification, structure and properties of amino acids b) Primary, secondary and tertiary structures of protein c) Ramachandran's plot	4
1.3	**Lipids** a) Storage Lipids (Fatty acids and Triacylglycerols) b) Structural Lipids (Phospholipids, Glycolipids, Sphingolipids and Sterols) c) Hormones (Eicosanoids & Steroids) and Vitamins (A, D, E & K)	3
1.4	**Components of enzymes and classification of enzymes** a) Structure and components of enzymes b) Classification of enzymes c) Properties of enzymes	3
1.5	**Michaelis-Menten equation and its applications** a) Derivation of Michaelis-Menten equation b) Lineweaver-Burke plots c) Enzyme kinetics for different types of inhibitors	2

UNIT 2	CARBOHYDRATE METABOLISM	
2.1	**Glucose Metabolism** a) Glycolysis and their regulation b) Fates of Pyruvate and gluconeogenesis c) Regulation of glycolysis and gluconeogenesis, Cori cycle	3
2.2	**Citric acid cycle** a) Reactions of the citric acid cycle b) Regulation of citric acid cycle c) Glyoxylate pathway and its regulation	3
2.3	**Oxidative phosphorylation** a) Components of electron transport chain b) Q-cycle, Coenzyme Q significance c) Mechanism of ATP synthesis	3
2.4	**Glycogen metabolism** a) Glycogenesis b) Glycogenolysis c) Regulation of Glycogenesis and Glycogenolysis	3
2.5	**Photosynthesis and pentose phosphate pathway** a) Light reaction-PS I and PS II b) Calvin cycle and pentose phosphate pathway c) C4, CAM and photorespiration	3
UNIT 3	**FATTY ACID, AMINO ACID AND NUCLEOTIDE METABOLISM, AND SIGNAL TRANSDUCTION**	
3.1	**Fatty acid metabolism** a) Beta oxidation and fatty acid biosynthesis b) Oxidation of unsaturated fatty acids c) Cholesterol metabolism	3
3.2	**Amino acid metabolism** a)Protein degradation and amino acid catabolism b) Urea cycle c)Biosynthesis of amino acids	3
3.3	**Nucleotide metabolism** a) Purine biosynthesis b) Pyrimidine biosynthesis c) Metabolism of non-carbohydrate molecules and signal Transduction	3
3.4	**Components and reactions of signal transduction** a) Types of signal transduction: Autocrine, Paracrine and Endocrine signaling b) Components of signaling pathways: Adapters and Secondary messengers c) Biochemical reactions in cellular signaling: Phosphorylation, Ubiqutination and Acetylation	3

3.5	**Signaling pathways** a) G-protein coupled receptor pathway-Structure of G proteins, GTPases) b) Signaling pathways of receptor tyrosine kinases c) Wnt (Canonical and non-canonical pathways) and Notch signaling pathways	3

PRACTICALS

G 153 P: PLANT FUNDAMENTALS OF BIOCHEMISTRY

S. No.	Topics to be covered
UNIT- I	
1.	Preparation of buffers and measurement of pH
2.	Qualitative tests for sugars
3.	Qualitative tests for amino acids
4.	Qualitative tests for lipids
5.	Paper chromatography
6.	Column Chromatography
7.	Estimation of Amylase Activity
UNIT-II	
8.	Isolation of proteins
9.	Estimation of proteins
10.	SDS-PAGE and transfer of western blots to membrane
11.	Detection of phosphorylated protein
12.	Estimation of LDH levels
13.	Starch gel electrophoresis
14.	Measurement of photosynthetic rate
15.	Measurement of respiratory quotient

BOOKS RECOMMENDED

1. Lehninger's principles of Biochemistry (David L. Nelson and Michael M. Cox)
2. Biochemistry (Jeremy M. Berg, John L. Tymoczko, LubertStryer)
3. Biochemistry (Donald Voet and Judith G. Voet)
4. Molecular biology of the cell. New York: Garland Science [Alberts, B., Johnson, A., Lewis,J., Raff, M., Roberts, K., & Walter, P. (2002)].

M.Sc. GENETICS I YEAR
SEMESTER- I
THEORY PAPER- IV
G104T: BIOSTATISTICS AND POPULATION GENETICS

1. Course Objectives (C. Obj.)

a. To learn the basics of biostatistics in designing experiments, analyzing experimental data, hypothesis testing and interpreting the results of biological data.
b. Understand the fundamental genetic principles governing variation of quantitative traits in populations, components of variance, heritability and inbreeding depression.
c. To learn the basic principles of population genetics and impact of evolutionary forces like mutation, selection and migration on genetic variation.

2. Course Outcomes (C. O)

a. Understand basic concepts in biostatistics for analyzing biological data.
b. Knowledge on quantitative traits and components of variance involved.
c. Knowledge of evolutionary factors that influence the genetic structure of populations.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**BIOSTATISTICS**	
1.1	**Introduction to Biostatistics** a) Population and Sample, Random sample, methods of sampling, sampling bias b) Types of Study designs c) Data and Types of variables, Levels/scales of variables	3
1.2	**Descriptive analysis of data** a) Data alignment and representation b) Measures of central tendency (Mean, median, modes c) Measures of dispersion (Range, standard deviation, mean deviation, variance, coefficient of variation), Skewness and Kurtosis	3
1.3	**Probability** a) Concept of probability, Types of events, Laws of probability (Addition and multiplication laws) b) Bayes theorem and its applications c) Probability distributions: Features and applications ofBinomial, Poisson and Normal distribution	3
1.4	**Tests of Hypothesis** a) Null and alternate hypothesis, test of significance, p-value, Type I and Type II errors, confidence intervals and confidence levels b) Test statistics: Z test (for proportions and means), t- test (students t-test, paired t-test). c) Analysis of categorical data-Chi-square test (test for goodness of fit, homogeneity test, linkage, test of independence); non-parametric tests.	3

1.5	**Multivariate analysis** a) Analysis of variance - One way and Two-way Anova (F- test) b) Correlation analysis (Simple and multiple correlation, methods of correlation, Coefficient of correlation (r), Pearson's correlation, Spearman's Correlation). c) Regression analysis (simple and multiple regressions, linear and curvi-linear regression, logistic regression)	3
Unit Number	**Topics to be covered**	**No. of lectures**
Unit 2	**QUANTITATIVE GENETICS**	
2.1	**Values and Means** a) Quantitative traits –features, population mean b) Average effect and breeding value c) Dominance deviation and interaction deviation	3
2.2	**Components of Variance** a) Phenotypic variance b) Genetic Variance- Additive and dominance variance c) Environment Variance-Multiple measurements and Repeatability	3
2.3	**Correlated characters** a) Genetic x Environmental correlations b) Genotype x Environment Interaction c) Correlated response to direction selection and indirect selection	3
2.4	**Resemblance between relatives** a) Genetic covariance-Offspring and one parent, Offspring and mid parent, Half sibs, full sibs and twins. b) Environmental covariance c) Phenotypic Resemblance	3
2.5	**Heritability and heterosis** a) Heritability –Types of heritability-(Narrow sense, broad sense), Estimation of heritability, Factors influencing heritability, Advantagesand limitations b) Genetic bases of heterosis, Fixation of heterosis, Factors affecting heterosis, estimation of heterosis and Inbreeding depression, Estimationof Inbreeding depression. c) Combining ability studies-Types of combining ability and estimation ofcombining ability- Applications and limitations	3

Unit Number	Topics to be covered	No. of lectures
Unit 3	**POPULATION GENETICS**	
3.1	**Random Mating Populations** a) Genetic properties of populations - Genotype and gene Frequencies b) Hardy-Weinberg Principle c) Extensions of Hardy-Weinberg Principle	3
3.2	**Systematic Forces** a) Mutation: Fate of single mutation, Forward and Reverse mutations, Recurrent Mutation, Impact of mutations on gene frequencies b) Selection: Types of Selection, Selection favoring heterozygotes, Selection against heterozygotes, complete elimination of recessives, Impact of selection and mutation on gene frequencies c) Migration-Effect of migration in small and large populations	3
3.3	**Dispersive Forces** a) Genetic drift- Founder effect and Bottle neck effect; Effective population size b) Inbreeding- effects of inbreeding, Assortative mating and its effects c) Gene flow and population structure	3
3.4	**Molecular Evolution** a) Molecular phylogeny of genes & proteins b) Neutral theory and molecular clock hypothesis c) Nearly Neutral theory	3
3.5	**Genome Evolution &Molecular Phylogenetics** a) Genome evolution - Gene Duplication, Exon Shuffling,Concerted Evolution, Transposition b) Phylogenetic tree construction- distance based methods c) Phylogenetic tree construction- character based methods	3

PRACTICALS

G154P: BIOSTATISTICS

S.No.	Topics to be covered
UNIT-I	**Unit I: Descriptive Statistics**
1.	Preparation of cross tabs, Construction of bar graphs, histogram,frequency polygon, pie diagram, box plot, scatter plot and data interpretation
2.	Estimation of Mean, Median and Mode for grouped and ungrouped data
3.	Estimation of Standard deviation, Variance, coefficient of variationand standard error; Sample size estimation
4.	Problems on probability and probability distributions
5.	Problems on Normal distribution
6.	Calculation of correlation coefficient
7.	Problems on linear Regression
8.	Calculation of slope from linear regression graph
UNIT-II	**Unit II: Inferential Statistics**
9.	Fisher Z transformation
10.	Hypothesis testing: Z test for means, Z test for proportions
11.	Hypothesis testing using t-test: Paired t-test, Unpaired t-test
12.	Hypothesis testing using Chi-square test: Goodness of fit, test ofindependence, 2 X 2 contingency, m X n contingency
13.	Hypothesis testing using F test: Problems on one-way ANOVA
14.	Hypothesis testing using F test: Problems on two-way ANOVA
15.	Data entry and analysis using excel/SPSS (Graphs)

BOOKS RECOMMENDED

1. Genetics of Population- Hedrick P.W. Jones & Bartlett.
2. Biostatistics, Wiley publications- Danial, W. W.
3. Fundamentals of Biostatistics, II Revised Edition, Ukaaz Publication - Khan & Khanum (2004).
4. Bailey, N.T.J, Statistical methods in Biology, Cambridge Univ. Press
5. Fundamentals of Biostatistics- P. Hanmanth Rao and K. Janardhan.
6. Introduction to Quantitative Genetics by Douglas S. Falconer and Trudy F.C. Mackay
7. Biometrical Techniques in Plant breeding by Phundan Singh and S.S. Narayanam
8. Population Genetics- C. C. Lee.

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for academic year 2022 onwards)

M.Sc. GENETICS I YEAR
SEMESTER – II

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G201T	Genome organization and maintenance	3	4	30	70	100
2.	G202T	Gene expression and regulation	3	4	30	70	100
3.	G203T	Plant Genetics and Molecular Breeding	3	4	30	70	100
4.	G204T	Human Genetics	3	4	30	70	100
PRACTICALS							
1.	G251P	Genome organization and maintenance	2	4		50	50
2.	G252P	Gene expression and regulation	2	4		50	50
3.	G253P	Plant Genetics and Molecular Breeding	2	4		50	50
4.	G254P	Human Genetics	2	4		50	50
		Total	**20**	**32**			**600**

M.Sc. GENETICS-I YEAR
SEMESTER- II
THEORY PAPER- I
G201T: GENOME ORGANIZATION & MAINTENANCE

1. Course Objectives (C. Obj.)

a. To impart knowledge on the structure of DNA, features of prokaryotic and eukaryotic genomes
b. To provide in-depth understanding of the process of genome replication and DNA recombination in different organisms
c. To provide knowledge on the types of DNA damage & their repair mechanisms and to give comprehensive understanding on the mechanisms of genome rearrangements

2. Course Outcomes (C.O)

a. Describe the basic structure of DNA and understand the salient features of prokaryotic and eukaryotic genomes
b. Comprehend the replication and recombination process in prokaryotic and eukaryotic genomes
c. Gain conceptual knowledge on the causes of mutation, DNA damage & their repair pathways and further comprehend different mechanisms of genome rearrangements

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Genome organization**	
1.1	**DNA structure** a) The genetic material: Discovery of DNA as genetic material, RNA as genetic material b) Constituents & chemical linkages in DNA, Double helical structure of DNA (Watson and Crick Model), alternative forms of DNA (A, B, C and Z), Chargaff's rule. c) Properties of DNA- DNA bending, DNA supercoiling, triplex-DNA, denaturation and renaturation (DNA-reassociation kinetics), C-Value paradox.	3
1.2	**Genome organization in prokaryotes** a) Genome packaging in prokaryotes- nucleoid, supercoiling, proteins involved in supercoiling. b) Genome organization in Archaea, Genome organization in Bacteria – genome size and structure, and organization. c) Bacterial genomes with primary and secondary chromosomes.	3
1.3	**Genome of Plasmids** a) Bacterial plasmids - organization, distribution and classification b) Plasmids in Archaea, Yeast plasmids c) Plant mitochondrial plasmids.	3

1.4	**Viral genome organization** a) General features of viral genomes -classification of viral genomes, DNA viruses-structure, composition, and organization of viral genomes (e.g., adenovirus2 genome). b) RNA viruses - structure, composition, and organization of viral genomes, segmentation in viral genomes (e.g., influenza virus genome), multipartite viral genomes (E.g. gemini virus genome) c) Bacteriophage and their genomes – diversity of bacteriophages, genome mosaicism of phages, phage M13 and lambda phage genome	2
1.5	**Eukaryotic genome organization** a) Complexity of nuclear genomes- Genome size, chromosome number, gene size, gene density and number of genes in eukaryotic cells. b) Repetitive DNA sequences- minisatellites & microsatellites, tandem and interspersed repeats; gene families (clustered and interspersed gene families), pseudogenes, structural features of transposons and retrotransposons c) Eukaryotic organellar genomes-features, genetic content & origin of mitochondrial & chloroplast genomes	4

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Genome Replication and Recombination**	
2.1	**DNA replication in prokaryotes** a) Models of DNA replication, origin of replication and replication fork, fidelity of DNA replication b) Replicons (Bacterial, Archeal), Bacterial replication –Process of replication, Function of Enzymes and proteins involved, rolling circle model, theta model c) Extra chromosomal replicons-plasmid replication	3
2.2	**DNA Replication in Eukaryotes** a) Features of Eukaryotic DNA replication, Enzymes and proteins of DNA replication, DNA polymerases and proof reading b) Process of Eukaryotic DNA replication, Centromere and Telomeric DNA replication, Regulation of DNA replication c) Organellar genome replication-mitochondria and chloroplast genome Replication ((D loop model and double D loop model)	3
2.3	**Genetic Recombination** a) DNA recombination and its significance in genome evolution. b) Chromosomal recombination, Overview of mitotic and meiotic recombination c) Mechanisms of genetic recombination in prokaryotes, Horizontal gene transfer – transformation, transduction, conjugation	3
2.4	**Homologous recombination** a) Recombination between homologous DNA – enzymes required for recombination in *E.coli*, mechanism of meiotic recombination, RecA, RecA homologs in eukaryotes b) Holliday junction model and Meselson Radding Model c) Gene conversion (double strand break model for recombination in yeast)	3

2.5	**Non-Homologous recombination** a) Mechanism of Non-homologous recombination *b)* Site specific recombination (integration of lambda DNA into *E.coli* genome) c) Replicative recombination	3
Unit Number	**Topics to be covered**	**No. of lectures**
UNIT 3	**DNA damage, DNA Repair and genome rearrangements**	
3.1	**DNA Mutations** a) Molecular mechanisms of mutations- transition and transversions b) Synonymous, missense and nonsense mutations c) Frameshift mutations, insertions and deletions	2
3.2	**DNA Damage** a) Causes of DNA damage- Spontaneous mutations, induced mutations- chemical agents & physical agents b) Types of DNA damages – oxidative damages, depurination, depyrimidination, O6-methylguanines, cytosine deamination, single and double strand breaks c) Effect of mutations on genome- hypermutation (programmed mutations)	3
3.3	**DNA Repair** a) DNA damage response- DNA damage sensors and cell fate b) Direct repair mechanisms- photoreactivation repair, excision repair system [base excision repair (BER) and nucleotide excision repair (NER)] mismatch repair (MMR), recombination repair (single and double strand break repair, non-homologous end joining (NHEJ) and homologous recombination (HR) pathway c) SOS repair, Translesion synthesis, genome instability and maintenance	4
3.4	**Genome rearrangements** a) Genome rearrangements – duplication, deletion, insertion, inversion & translocation, mechanisms of duplication (Whole genome duplication), Role in genome evolution b) General features of unprogrammed transposition, types of mobile elements, mechanisms of transposition c) Programmed rearrangements (flip-flop inversions, yeast mating types); Programmed amplification (Drosophila chorion genes, Xenopus rDNA, Tetrahymena rDNA)	3
3.5	**Transposable elements** a) Prokaryotic transposable elements- IS elements, simple and composite transposons b) P elements of Drosophila; controlling elements of Maize c) Retrotransposons- class I retrotransposons, Ty elements, Copia elements, IAP sequences of mice, class II retrotransposons, - F, G & I elements in Drosophila, LINES in mammals; Retrogenes.	3

PRACTICALS

G251P: GENOME ORGANIZATION & MAINTENANCE

S. No.	Topic to be covered
UNIT-1	
1	Isolation of genomic DNA from plant tissue
2	Isolation of genomic DNA from microorganisms
3	Isolation of genomic DNA from human blood
4	Method for plasmid isolation
5	Measuring plasmid copy number
6	Problems on DNA-reassociation kinetics
7	Tm determination of DNA- Cot analysis
UNIT-2	
8	Method for detecting plasmid DNA conformations
9	Method to detect plasmid transfer
10	Induction of mutants using chemical agents
11	Detection of recombination in bacteria
12	Induction of mutagenesis using UV radiation
13	Photorepair of UV-damaged DNA
14	DNA ligation
15	Determination of DNA damage by Comet assay

BOOKS RECOMMENDED

1. Genes & Genomes – A changing perspective by Singer & Berr, Universal Science Books,California.
2. Gene XII/XI/X by Benjamin Lewin, Jones & Bartlet publishers.
3. Genomes. 2nd edition. Brown TA. Oxford: Wiley-Liss; 2002; Genetics -A Conceptual Approach by Benjamin A. Pierce.
4. Molecular Biology of the Cell. 4th edition by Alberts B, Johnson A, Lewis J, et al. New York:Garland Science; 2002.
5. The Cell: A Molecular Approach. 2nd edition. by Cooper GM. Sunderland (MA): Sinauer Associates; 2000.
6. Molecular Biology of the Cell. 4th edition by Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.
7. DNA Damage Repair, Repair Mechanisms and Aging by Allison E. Thomas Nova Science Publishers, 2010.
8. Chromosomal Translocations and Genome Rearrangements in Cancer by Janet D. Rowley, Michelle M. Le Beau, Terence H. Rabbitts Springer International Publishing, 2015.

M.Sc. GENETICS- I YEAR
SEMESTER- II
THEORY PAPER- II
G202T: GENE EXPRESSION AND REGULATION

1. Course Objectives (C. Obj.)

a. To provide knowledge on the structure and organization of prokaryotic and eukaryotic genes; To describe the process of transcription and translation in prokaryotes and eukaryotes
b. To enable comprehensive understanding of the regulation of gene expression
c. To give insights on epigenetic modifications in the regulation of gene expression

2. Course Outcomes (C.O)

a. Recognize and apply gene organization elements in prokaryotic and eukaryotic systems; Analyze gene expression changes in prokaryotes and eukaryotes
b. Identify differential regulatory mechanisms of gene expression
c. Classify epigenetic modifications and identify their role in gene expression

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**Gene structure, organization and expression**	
1.1	a) Structure of prokaryotic genes(promoter elements, coding region, terminal region, colinearity & polycistronic mRNA) b) Structure of Eukaryotic genes ((introns, exons, UTRs, core & proximal promoters, enhancers, silencer, monocistronic mRNA)) c) Complexity in gene organization- Overlapping genes and bidirectional genes	2
1.2	**Operons** a) Operon concept-Organization of prokaryotic genes into operons b) Inducible operon- Lac operon (structural genes, lac repressor & CAP) c) Repressible operon- Trp operon (structural genes, trp repressor & attenuation)	3
1.3	**Protein and RNA coding genes** a) Organization of mRNA genes b) Organization of rRNA and tRNA genes c) Regulatory small RNA coding genes (siRNAs, miRNAs, long non-coding RNAs)	3

1.4	**Gene Transcription** a) Transcription in prokaryotes-Prokaryotic RNA Polymerases,Process of transcription -initiation, elongation, rho- dependent and independent termination) b) Transcription in eukaryotes- RNA Polymerases (Type I, II and III), Basal and specific transcription factors, Transcription activators and repressors, Process of transcription (initiation, elongation and termination for Class I , II and III genes) c) Transcription in mitochondria and chloroplast	4
1.5	**Gene Translation** a) Process of translation in Prokaryotes b) Translation in Eukaryotes- Ribosome assembly, Aminoacyl tRNA synthetases, Translation factors, Process of translation) c) Features of Genetic code, Wobbles hypothesis, codon-bias	3

Unit Number	Topics to be covered	No. of lectures
Unit 2	**Gene Expression and regulation**	
2.1	**Post-transcriptional modifications** a) mRNA capping and poly-adenylation b) Splicing (spliceosome assembly, process of splicing, self-splicing, Trans-splicing) c) Alternate splicing (Exon skipping, intron inclusion, alternate splice sites, 5'end variations, 3'end variations); RNA transport and Stability	4
2.2	**Post-transcriptional regulation of gene expression** a) Modes/factors in regulation - Proximal promoter, specific transcription factors, enhancers, multiple promoters, alternate transcription initiation sites, multiple PolyA sites b) Regulation- Chicken globin genes, genes controlling yeast mating type, and Xenopus 5S rRNA in oocytes c) Gene silencing	3
2.3	**Post-translational processes** a) Protein modifications (Phosphorylation, acetylation, methylation, ubiquitinylation) b) Protein turnover and underlying mechanisms c) Protein-protein interactions (PPIs); techniques to study PPIs	3
2.4	**Regulation of gene expression** a) Tissue-specific regulation of gene expression b) Regulation of gene expression during development of an organism-class switching (Alpha and Beta Globin gene expression) c) Altered gene expression- HOX genes in drosophila	3
2.5	**Techniques to analyze differential gene expression** a) Gene expression analysis by qRT-PCR and Microarrays b) RNA sequencing and transcriptome analysis c) Mass spectrometry based proteomics, Western blotting	2

Unit Number	Topics to be covered	No. of lectures
Unit 3	**Epigenetic Regulation of GeneExpression**	
3.1	**Basic concepts of Epigenetics** a) History and overview of epigenetics-Nature Vs Nurture b) Epigenetic aspects in plants c) Epigenetic mechanisms in animals	2
3.2	**DNA and Histone modifications** a) DNA methylation, CpG islands, b) Histone modifications in chromatin regulation (Acetylation, methylation, phosphorylation); Histone code c) Chromatin remodelling in regulation of transcription: chromatin modifying enzymes and complexes (HATs, HDACs, SWI/SNF)	4
3.3	**Epigenetic Inheritance** a) Dosage compensation and epigenetic process, b) Genome imprinting and epigenetic reprogramming (Erasure, establishment and maintenance of epigenetic marks); c) Regulators of homeotic genes—PcG and TrxG proteins	3
3.4	**Regulation of epigenetic process** a) Small RNAs in epigenetic regulation b) LncRNAs in epigenetic regulation c) Epigenetic regulation by environmental factors	3
3.5	**Techniques used in epigenetic studies** a) Methylation specific PCR, Bisulfite sequencing, b) Analysis by Chip-Sequencing method c) Hi-C analysis	3

PRACTICALS
G252P: GENE EXPRESSION AND REGULATION

S.No.	Topics to be covered
UNIT-1	
1.	RNA isolation from blood
2.	RNA isolation from plants
3.	RNA integrity by agarose gel electrophoresis
4.	Estimation of RNA
5.	Designing of primers
6.	cDNA synthesis
7.	Interpretation of DNA sequence chromatograms
8.	Insilico prediction of Transcription start sites
UNIT-II	
9.	qRT-PCR analysis by SYBR green assay
10.	qRT-PCR set up by Taqman assay
11.	Calculation of Rq value by Delta-Delta Ct method
12.	Elution of DNA band from agarose gel
13.	Preparation of competent cells
14.	Methylation specific PCR
15.	Induction of Lac operon

BOOKS RECOMMENDED

1. Lewin's Genes XI (Jocelyn E. Krebs, Benjamin Lewin, Elliott S. Goldstein, Stephen T. Kilpatrick)
2. Molecular biology of the Gene (James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick)
3. Genomes 4 (T.A. Brown)
4. Molecular Biology of the Gene by James D. Watson ,A. Baker Tania ,P. Bell Stephen,Gann Alexander, Levine Michael, Losick Richard (Pearson 7thEdition)
5. Molecular Biology of the Cell by Bruce Alberts, Alexander D. Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts-6thEdition
6. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp, James G. Patton-7thEdition
7. Genes & Genomes – A changing perspective by Singer & Berr, Universal Science Books,California
8. Modern Genetic Analysis by Griffiths AJF, Gelbart WM, Miller JH
9. Regulation of Gene Expression by Small RNAs-edited by Rajesh K. Gaur, John J. Rossi, Taylor and Francis group (2009)
10. Gene Regulation by David Latchman, Taylor and Francis group, 2005

M.Sc. GENETICS I YEAR
SEMESTER- II
THEORY PAPER- III
G203T: PLANT GENETICS AND MOLECULAR PLANT BREEDING

1. Course Objectives (C. Obj.)

a. To provide knowledge about principles of plant breeding and methods of plant breeding
b. To impart knowledge on specific breeding methods for biotic stress resistance and abioticstress tolerance
c. To explain the importance of plant tissue culture and molecular methods of breeding

2. Course Outcomes (C. O)

a. Identify and apply different plant breeding methods
b. Apply the concepts of plant breeding for biotic stress resistance, abiotic stress tolerance and economically important traits
c. Knowledge regarding the *in vitro* methods and molecular aspects of plant breeding

Unit Number	Topics to be covered	No. of lectures
Unit 1	**Principles of plant breeding**	
1.1	**Introduction to plant breeding :** a) History of plant breeding – role of plant breeding in society. b) Domestication of crop plants – centres of origin and diversity. c) Basic features of plant breeding - objectives of plant breeding.	2
1.2	**Reproductive systems in plants:** a) Sexual reproduction – self and cross fertilization; mechanisms promoting self and cross pollination, autogamy, allogamy; genetic consequences of self and cross fertilization. b) Asexual reproduction- vegetative reproduction, apomixis, genetic consequences of asexual reproduction. c) Mating systems and genetic consequences.	4
1.3	**Breeding methods in self-pollinating crops:** a) Pure line selection & Pedigree methods -genetic basis, procedure, merits and limitations, achievements. b) Back cross method – genetic basis, procedure, dominant and recessive gene transfer, advantages, limitations, achievements. c) Bulk population method- procedure, genetic basis, advantages, limitations, modifications.	3
1.4	**Breeding methods in cross pollinating crops:** a) Selection methods –mass selection, family selection, recurrent selection methods. b) Hybrid breeding – development and evaluation of inbred lines; A, B and R lines, male sterility systems, development of hybrids, c) Synthetic and composite varieties – procedure, genetic basis, merits, limitations and achievements.	3

1.5	**Non-conventional breeding methods :** a) Wide hybridization - Inter-specific crosses and inter-generic hybridization; role of wide hybridization in crop improvement. b) Mutation breeding- mutagens and induced mutagenesis, procedure, uses of TILLING for crop improvement. c) Polyploidy breeding - origin, types, breeding autopolyploid, applications of allopolyploidy.	2

UNIT 2	**Specific Breeding Methods**	
2.1	**Breeding for biotic stress resistance** a) Disease resistance -genetics of pathogenicity, genetics of disease resistance. b) Methods of breeding for disease resistance- multilines. c) Pest resistance- mechanisms of insect pest resistance, breeding methods for insect and pest resistance.	3
2.2	**Breeding for abiotic stress tolerance** a) Drought tolerance – stress and tolerance mechanism and conventional breeding for drought tolerance. b) Salinity tolerance– mechanism and conventional breeding for salinity tolerance. c) Temperature tolerance – stress and tolerance mechanism and conventional breeding for cold stress and heat stress tolerance.	3
2.3	**Breeding for abiotic stress tolerance** a) Flooding tolerance– stress and tolerance mechanism and conventional breeding for flooding tolerance. b) Mineral toxicity resistance – stress and tolerance mechanism and conventional breeding for resistance to mineral toxicity. c) Mineral deficiency – mechanism and conventional breeding for mineral deficiency.	3
2.4	**Breeding for traits** a) Breeding for yield and morphological traits – ideotype concept, lodging and shattering resistance, reduced plant height, determinacy, photoperiod response, early maturity b) Breeding for quality traits - improved protein content, improved oil quality, enhanced bioavailable micronutrients. c) Breeding for end use quality - low phytate, delayed ripening.	3
2.5	**Variety Release Process** a) Cultivar release process – release and notification of variety in India. b) Seed certification and multiplication – classes of seeds, generation system for seed multiplication. c) Plant variety protection– UPOV, Plant breeder's rights, farmer's rights. PVP&FR Act 2001	3

UNIT 3	In vitro Plant Breeding & Molecular Plant Breeding	
3.1	**Introduction to plant tissue culture** a) Historical developments – role of plant tissue culture in plant breeding b) In vitro differentiation and morphogenesis- cellular totipotency, polarity, organogenesis, somatic embryogenesis. c) Initiation of plant tissue culture - explant preparation, nutrient media, callus culture, single cell culture.	3
3.2	**Plant tissue culture techniques in breeding** a) Micropropagation- stages of micropropagation, applications of micropropagation. b) Haploids and di-haploids in breeding- production and applications in plant breeding. c) Somaclonal variations – mechanisms, role in crop improvement.	3
3.3	**Plant tissue culture techniques in breeding** a) Somatic hybridization – isolation, fusion, selection and identification of protoplasts, protoplast culture and regeneration, nuclear hybrids, cybrids, role in crop improvement, b) Somatic embryogenesis – stages & patterns, factors affecting somatic embryogenesis, role in plant breeding. c) Plant genetic resources conservation – germplasm evaluation, conservation approaches, utilization, National Germplasm Banks.	3
3.4	**Plant tissue culture techniques in breeding** a) Plant genetic transformation - physical, chemical, biological (Agrobacterium mediated, viral mediated), in planta transformation methods. b) Transgenics – utility and limitations in production of herbicide resistant crops. c) Cisgenics & intragenics – cisgenesis, intragenesis, role in plant breeding.	3
3.5	**Molecular plant breeding tools and methods** a) Molecular marker systems -hybridization based markers, PCR based markers, DNA sequence-based markers, applications of molecular markers b) Marker -trait association - Mapping of genes, types of gene maps, mapping populations, linkage mapping, QTL mapping, association mapping. c) Marker assisted breeding (MAB) – prerequisites and activities of MAB; procedure and practical applications of marker assisted selection (MAS), marker assisted backcrossing (MABC), marker assisted gene pyramiding and marker assisted recurrent selection.	3

PRACTICALS

G 253 P: PLANT GENETICS AND MOLECULAR PLANT BREEDING

S. No.	Topics to be covered
UNIT- I	
1	Floral morphology- self-pollinating and cross-pollinating crops
2	Pollination methods- self-pollinating and cross-pollinating crops
3	Breeding methods – emasculation, hybridization techniques, types of crosses
4	Rice and maize breeding
5	Estimation of heterosis and inbreeding depression
6	Estimation of variability parameters
7	Field experimentation – random block design
UNIT-II	
8	Tissue culture media – preparation and sterilization
9	Explants - preparation and aseptic culture
10	Callus culture - induction of organogenesis
11	Somatic embryogenesis – preparation of synthetic seeds
12	Protoplast - isolation and culture
13	Anther/pollen culture
14	Embryo culture
15	RAPD/SSR analysis

BOOKS RECOMMENDED

1. Principles of Plant Genetics and Breeding (2020) by George Acquaah, Third Edition Wiley-Blackwell Publishers.
2. Molecular Plant Breeding (2010) by Yunbi Xu, MPG Books Group Publishers.
3. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches (2002) by G.S. Chahal, S.S. Gosal, Alpha Science International Ltd. Harrow, U.K.
4. General Plant Breeding (2006) by A.R. Dabholkar Concept Publishing Company, New Delhi.
5. Plant Tissue Culture: Techniques and Experiments (2013) by Roberta H. Smith, Academic Press, U.K.
6. Plant Tissue Culture and Biotechnology: Emerging Trends (2003) by P.B. Kavi Kishor, Universities Press.
7. Plant Tissue Culture: Basic and Applied (2005) by Timir Baran Jha, Universities Press.
8. Plant Biotechnology: Practical Manual (2007) by C. C. Giri, Archana Giri, I.K International Publishers.
9. Plant Biotechnology and Agriculture: Prospects for the 21st Century by Arie AltmanProfessor, Paul Micheal Hasegawa. Academic Press; 1st edition

M.Sc. GENETICS I YEAR
SEMESTER- II

THEORY PAPER- IV
G204T: HUMAN GENETICS

1. **Course Objectives (C. Obj.)**
   a. To provide insights on patterns of inheritance of human genetic traits, segregation analysis and to describe human genome organization.
   b. To enable understanding of molecular mechanisms in disease pathology
   c. To explain about linkage analysis, genetic association studies, strategies for identification and mapping of genes

2. **Course Outcomes (C. O)**
   a. Identify and establish genetic basis of a trait through analysis of pedigrees
   b. Gain knowledge regarding the molecular mechanisms in disease pathology
   c. Apply the concepts of linkage analysis for gene mapping and utilize strategies to localize and map genes.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**Transmission of genetic traits and human genome organization**	
1.1	**Modes of Inheritance** a) Pedigree analysis, Autosomal dominant and recessive traits, b) X-linked dominant and recessive traits, Y-linked inheritance c) Sex influenced and sex limited traits, Maternal inheritance	3
1.2	**Extensions to Mendelian inheritance** a) Incomplete penetrance and variable expressivity, delayed age at onset, Anticipation b) Genetic and phenotypic heterogeneity, Epistasis, Pleiotropism c) Gametic imprinting, Mosaicism andUniparental Disomy	3
1.3	**Segregation analysis for monogenic traits** a) Segregation analysis for Autosomal and X-linked dominant conditions b) Segregation analysis for autosomal recessive traits under Complete ascertainment-Apriori method, MLE method, Singles method c) Incomplete ascertainment- Sib method and Proband method	3
1.4	**Complex traits and Multifactorial inheritance** a) Features of complex/ quantitative traits, Liability and Threshold model b) Twin and adoption studies in genetic analysis c) Heritability of traits and methods of estimation (IQ, hypertension, dermatoglyphic traits, facial dysmorphology)	3
1.5	**Human Genome organisation** a) Nuclear genome [Gene number, Gene density, Gene size, exon content of genes, CpG islands, coding and non-coding genes, overlapping genes, Highly Repetitive sequences [satellite DNA (alphoid satellite, VNTRs, microsatellites), LTR, DNAtransposons, Retro transposons, SINES (Alu repeats), LINES (L1 family)]	3

	b) Gene families- Globin gene cluster, Histone gene cluster, Immunoglobulin super family, rRNA gene families; Pseudogenes (processed and non-processed) c) Human mitochondrial genome	
Unit Number	**Topics to be covered**	**No. of lectures**
Unit 2	**Human molecular genetics**	
2.1	**Molecular mechanisms in phenotype expression** a) Molecular explanation for dominance and recessiveness b) Molecular mechanisms for reduced penetrance and expressivity c) Pleiotropism and its molecular basis	3
2.2	**Epigenetic modulations and parent-of-origin effects** a) Molecular mechanisms for X-chromosome inactivation (control of X-linked gene dosage, XIC locus, regulation of XIST and TSIX, escape of X-chromosome inactivation). b) Genomic imprinting – Imprinting for monoallelic expression and its maintenance, imprinted genes cluster (11p15.5, 15q11-q13-associated with Prader-Willi and Angelman syndrome; H19/IGF2 cluster). c) Mechanisms of Uniparental disomy, Mosaicism and Chimerism; maternal effects and mitochondrial traits.	3
2.3	**Gene mutations and function** a) Loss of function mutations: In coding sequences (β-Globin gene); Splice junction mutations – Acceptor and Donor splice site mutations – DMD, NF1and CFTR b) Gain of function mutations: Dominant negative effect (collagen gene mutations); Gene dosage effect (PMP22 gene) c) Inappropriate gene expression- ectopic expression, echronic expression, expression of fusion genes, position effect variegation.	3
2.4	**Gene amplification and expansion of repeat sequences** a) Dynamic mutations and anticipation. b) Gene amplification and functional consequence (e.g., HER2 gene, MYC gene). c) Mechanisms of Trinucleotide expansion and its detection in human disorders (e.g., Huntingtons disease, Fragile X syndrome)	3
2.5	**Molecular genetics of complex phenotypes and cancer** a) Complex genetic diseases –Diabetes mellitus, Coronary Artery Disease b) Genetic basis of Cancer – Oncogenes, tumor suppressor genes, mutator genes. Somatic vs germ line mutations c) Cancer signaling pathways, Genomic instability in cancer,Telomerase dysfunction in aging and cancer.	3

Unit Number	Topics to be covered	No. of lectures
Unit 3	**Linkage analysis and mapping human traits**	
3.1	**Linkage analysis for gene mapping** a) Concept of Linkage, Physical mapping Vs genetic mapping b) Types of markers for linkage detection (blood groups, secretor status, PTC tasting, RFLP markers, VNTR markers, SSR markers, and microsatellite markers) c) Parametric methods of linkage (LOD score, sib-pairmethod), Limitations of parametric method of linkage analysis.	3
3.2	**Non-parametric methods of linkage (NPL) and multipoint mapping** a) Allele sharing methods(Identical by Descent, affected sibs method), Challenges in NPL methods. b) Extensions of linkage studies for reduced penetrance c) Multipoint linkage analysis, Homozygosity mapping for recessive diseases, transmission disequilibrium test (TDT)	3
3.3	**Genetic association studies** a) SNP analysis (Genetic models and Allelic effects), GWAS b) Haplotype analysis, mapping of complex traits, Population based studies c) Linkage disequilibrium analysis.	3
3.4	**Strategies for Disease Gene Identification-** a) Approaches for disease gene identification, Functional cloning (Eg: Hemophilia), b) Positional dependent cloning (Eg: DMD, Chronic Granulomatous disease, Cystic Fibrosis), c) Position independent cloning and Candidate gene approach (Eg: Marfan's Syndrome, Retinitis Pigmentosa)	3
3.5	**Methods of gene mapping** a) Low resolution mapping methods (sub-chromosomal mapping, Somatic cell hybrid and radiation hybrid mapping) b) High resolution mapping methods c) Human genome project- Goals, achievements, strategies and ethical concerns, Progress of genome projects-. 1000 Genome project, HapMap project, ENCODE project.	3

PRACTICALS

G254P: HUMAN GENETICS

S.No.	Topics to be covered
UNIT-I	**Genetic epidemiology and population genetics**
1.	Construction of Pedigrees
2.	Identification of modes of inheritance from pedigrees
3.	Segregation analysis for autosomal dominant and recessive traits (Single's method, Sib method and Proband method)
4.	Estimation of heritability for a complex trait
5.	Estimation of allele and genotype frequencies
6.	Testing for Hardy-Weinberg Equilibrium
7.	Calculation of inbreeding coefficient from pedigrees
8.	
UNIT-II	**Gene mapping and Mutation detection**
8.	Estimation of Odds ratio and recurrence risk
9.	Estimation of LOD score from pedigrees
10.	Linkage detection by Sib pair method
11.	Localization of gene by Haplotype analysis/ Transmission disequilibrium test
12.	Genotype analysis by PCR based methods using RFLP markers
13.	Genotype analysis by PCR based methods using VNTR markers
14.	Genotype analysis by PCR based methods using microsatellite markers
15.	Detection of triplet nucleotide repeat expansion

BOOKS RECOMMENDED

1. Cummings, M.R. (2009). Human Heredity: Principles and Issues. Pacific Grove, Pub: Australia Brooks/Cole Cengage Learning, 8th Edition.
2. R. F. Mueller and I.D Yound (2001) Emery's Elements of Medical Genetics, 11th Edition.
3. R. F. Mueller and I.D Yound (2001) Emery's Elements of Medical Genetics, 11th Edition.
4. The principles of human biochemical genetics. By Harry Harris. North-Holland, Amsterdam; American Elsevier, New York. 328 pp. 1970
5. Curt Stern (1960) Principles of Human Genetics, Publisher: W. H. Freeman & Company; 2nd Edition.
6. Robert et al., (2015) Thompson and Thompson Genetics in Medicine, Elsevier, Saunders, London
7. Gardner, A. and Davies, T. (2009) Human Genetics-Scion Publishing, 2nd Edition.
8. Lewis, R. (2008) Human Genetics: Concepts and Applications, McGraw-Hill Publishing, New York, 8th Edition.
9. Tom Strachan and Andrew Read (2011) Human Molecular Genetics, Garland Science/Taylor & Francis Group, 4th Edition.