M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
Scheme of Examination-Continuous Comprehensive Evaluation (CCE)
(Proposed for academic year 2023 onwards)

M.Sc. GENETICS
I YEAR SEMESTER– I

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ Week	Marks						
					Internal Assessment					Semester Exam	Total
					I	II	III	IV	Attendance		
1.	G101T	Principles of Inheritance	3	4	10	10	10	10	10	50	100
2.	G102T	Cell Biology & Cytogenetics	3	4	10	10	10	10	10	50	100
3.	G103T	Fundamentals of Biochemistry	3	4	10	10	10	10	10	50	100
4.	G104T	Biostatistics and Population Genetics	3	4	10	10	10	10	10	50	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 COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for year 2022-24)

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, maskinggene 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 strainin 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-Hill Book 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
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Scheme of Examination-Continuous Comprehensive Evaluation (CCE)
(Proposed for academic year 2023 onwards)

M.Sc. GENETICS
I YEAR SEMESTER – II

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ Week	Marks						
					Internal Assessment					Semester Exam	Total
					I	II	III	IV	Attendance		
1.	G201T	Genome organization and maintenance	3	4	10	10	10	10	10	50	100
2.	G202T	Gene expression and regulation	3	4	10	10	10	10	10	50	100
3.	G203T	Plant Genetics and Molecular Breeding	3	4	10	10	10	10	10	50	100
4.	G204T	Human Genetics	3	4	10	10	10	10	10	50	100
PRACTICALS											
1.	G251P	Genome organization and maintenance	2	4							50
2.	G252P	Gene expression and regulation	2	4							50
3.	G253P	Plant Genetics and Molecular Breeding	2	4							50
4.	G254P	Human Genetics	2	4							50
		Total	**20**								**600**

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for year 2022-24)

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 ofrecombination 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.

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
Scheme of Examination-Continuous Comprehensive Evaluation (CCE)
(Proposed for academic year 2023 onwards)

M.Sc. GENETICS
II YEAR SEMESTER – III

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ Week	Marks						
					Internal Assessment					Semester Exam	Total
					I	II	III	IV	Attendance		
1.	G301T	Genetic Engineering	3	4	10	10	10	10	10	50	100
2.	G302T	Immunogenetics	3	4	10	10	10	10	10	50	100
3.	GE303T	**ELECTIVE 1:** 1A. Medical Genetics(or) 1B. Mouse Genetics &Disease Models	3	4	10	10	10	10	10	50	100
4.	GE304T	**ELECTIVE 2:** 2A. Plant Genomics &Biotechnology (or) 2B. Plant Nutraceuticals & Nutrigenomics	3	4	10	10	10	10	10	50	100
PRACTICALS											
1.	G301T	Genetic Engineering	2	4							50
2.	G302T	Immunogenetics	2	4							50
3.	GE353P	1A. Medical Genetics(or) 1B. Mouse Genetics & Disease models	1	2							25
4.	GE354P	2A. Plant Genomics &Biotechnology (or) 2B. Plant Nutraceuticals & Nutrigenomics	1	2							25
		Seminars	2								50
		Total	**20**								**600**

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for year 2022-24)

M.Sc. GENETICS
II YEAR SEMESTER – III

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G301T	Genetic Engineering	3	4	30	70	100
2.	G302T	Immunogenetics	3	4	30	70	100
3.	GE303T	**ELECTIVE 1:** 1A. Medical Genetics (or) 1B. Mouse Genetics & Disease Models	3	4	30	70	100
4.	GE304T	**ELECTIVE 2:** 2A. Plant Genomics &Biotechnology (or) 2B. Plant Nutraceuticals &Nutrigenomics	3	4	30	70	100
PRACTICALS							
1.	G351P	Genetic Engineering	2	4			50
2.	G352P	Immunogenetics	2	4			50
3.	GE353P	1A. Medical Genetics (or) 1B. Mouse Genetics & Disease models	1	2			25
4.	GE354P	2A. Plant Genomics & Biotechnology (or) 2B. Plant Nutraceuticals & Nutrigenomics	1	2			25
		Seminars	2				50
		Total	**20**				**600**

M.Sc. GENETICS II YEAR
SEMESTER- III

THEORY PAPER- I
G301T: GENETIC ENGINEERING

1 Course Objectives (C. Obj)

a. To learn about the basic components of molecular cloning
b. Understand molecular approaches and techniques related to genetic engineering
c. To comprehend gene manipulation techniques and their applications

2 Course Outcomes (C.O)

a. Understanding the fundamentals of cloning processes and components involved.
b. Comprehension of various molecular biology techniques and their applications; Acquaintance with recombinant DNA and DNA sequencing techniques.
c. Knowledge regarding the gene manipulation and use of rDNA techniques in modern biology, medicine and agriculture

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**BASICS OF MOLECULAR CLONING**	
1.1	**Introduction to molecular cloning** a) Advent of rDNA Technology b) Importance of genetic engineering c) Steps in gene cloning	3
1.2	**DNA modifying enzymes** a) Properties and applications of DNA modifying enzymes b) Restriction endonucleases & types (Type I to type IV); host- controlled restriction modification system, isoschizomers c) Modifying enzymes - methyltransferases, polymerases, kinases, phosphatases, nucleases, terminal transferase and ligases	3
1.3	**Cloning vectors** a) Properties of cloning vectors b) Types of cloning vectors – plasmids, Lambda-based vectors and derivatives (insertion vectors, replacement vectors, cosmids, phasmids & phagemids); c) Tags, Selection markers	3
1.4	**High-cloning capacity vectors** a) Single stranded DNA vectors (M13) b) YACs, BACs, PACs c) Expression vectors- pET , GST, MBP	3
1.5	**Hosts used in genetic engineering** a) Prokaryotic hosts- Escherichia coli, Bacillus subtilis; Baculovirus b) Eukaryotic host –Yeast c) Plant and animal cells- SF4, SF21, HEK293	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Cloning Strategies and screening of recombinant clones**	
2.1	**Generalized cloning strategies** a) Generation and purification of vectors and inserts b) Restriction digestion, modification and ligation c) Transformation of bacteria, screening of positive clones	3
2.2	**Construction of libraries** a) Strategies for construction of genomic libraries: selection of vectors, screening methods b) Positional cloning (chromosome walking & chromosome jumping) c) Construction of subtractive and normalized cDNA libraries & its advantages	3
2.3	**Techniques in rDNA Technology** a) PCR –Principle, Types and applications (Inverse PCR, Nested PCR, RT-PCR) b) Hybridization techniques- Principle, Types (Northern, Southern &Western blotting, dot-blot & colony hybridization), colony PCR c) Labeling of nucleic acids- 3′ end labeling & 5′ end labeling, random priming & nick translation using radioactive & non-radioactive probes	3
2.4	**Selection and screening of recombinants** a) Genetic selection- insertional inactivation and alphacomplementation b) Immunological screening, screening by Hybrid arrest and Hybrid released translation c) Isolation of individual genes by complementation assay & contig Assembly	3
2.5	**DNA sequencing methods** a) Maxam-Gilbert and Sanger's method b) Automated sequencing, multiplex sequencing c) Next Generation Sequencing (principle & its applications), Third generation Nanopore	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**TECHNOLOGIES FOR GENETIC MANIPULATION**	
3.1	**Genetic manipulation** a) Mapping of restriction sites b) S1 mapping c) Site directed mutagenesis	3
3.2	**Screening methods and functional analysis** a) PCR-based methods for screening for mutants b) Methods of mutagenesis c) Complementation assays	3

3.3	**Gene silencing technology** a) Anti-sense Technology b) siRNA and microRNA mediated gene silencing invitro c) Triplex forming oligonucleotides (TFO) for gene silencing	3
3.4	**Transgenic technologies** a) Transgenic technology: construct design and cloning, electroporation, screening, microinjection and genotyping applications b) Gene knock-in technologies: methodology and applications c) Gene knock-out technologies: methodology and applications	3
3.5	**Genome editing technologies** a) CRISPR-CAS system, b) TALENs & Zinc finger Nucleases c) Applications and limitations of genetic engineering- in agriculture, animalhusbandry, medicine & industry	3

PRACTICALS

G351P: GENETIC ENGINEERING

S. No.	Topics to be covered
1	Identification of Plasmids for cloning
2	Preparation of inserts -Restriction digestion
3	Designing of adapters
4	Construction of vector(s)
5	Genetic transformation
6	Selection of recombinant clones-Blue-white screening
7	Polymerase chain reaction for confirmation of recombinants
8	Southern blotting technique
9	Site-directed mutagenesis –for insertion/deletion
10	Site-directed mutagenesis –for substitution
11	Restriction mapping problems
12	DNA sequence analysis problems
13	Expression of cloned genes by Western Blot
14	Expression of a cloned gene by qRT-PCR
15	siRNA mediated down regulation of a gene

REFERENCE BOOKS

1. Principles of Gene Manipulation and Genomics- Sandy B. Primrose, Richard Twyman 7th Edition; Blackwell Publishing
2. Gene Cloning and DNA Analysis: An Introduction- T. A. Brown- John Wiley & Sons
3. An Introduction to Genetic Engineering- Desmond S.T. Nicholl-Cambridge University Press
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten - ASM Press
5. Sambrook, J., Fritsch, E. R., & Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

M.Sc. Genetics-II YEAR
SEMESTER- III
THEORY PAPER- II
G302T- IMMUNOGENETICS

Course Objectives (C.Obj)

a. To give an overview of different types of immunities, cells & organs involved in the immune system and to provide the insights into immunogenicity and antigenicity.
b. To understand the structure and function of immunoglobulins and their generation, and to gain knowledge on structure and function of Major Histocompatibility Complex
c. To provide the comprehensive understanding of the cell mediated immune responses & in-depth knowledge about autoimmunity & immunodeficiency disorders.

Course Outcomes (C.O)

a. Basic understanding and importance of the immune system.
b. The importance and applications of immunoglobulins in therapeutics can be known and to appreciate the importance of MHC in organ transplantation
c. Knowledge about the cell mediated immune responses and awareness regarding autoimmune and immunodeficiency disorders.

Course Plan/Schedule:

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Basics principles of Immunology**	
1.1	**Immunity– Types of Immunity** a) Innate immunity- Anatomic barriers, physiological barriers, phagocytic barriers b) Innate Immunity-microbial antagonism, inflammation c) Acquired Immunity– Types & characteristics	3
1.2	**Cells of the Immune System** a) Haematopoiesis and differentiation b) Lymphoid cells (B & T-Lymphocytes; T cell subsets; NK cells), c) Myeloid cells: Mononuclear phagocytes (monocytes, macrophages) Granulocytes (neutrophils, eosinophils, basophils, mast cells, dendritic cells)	3
1.3	**Organs of the immune system** a) Primary lymphoid organs (Bone marrow and Thymus) b) Secondary lymphoid organs (lymph nodes, spleen) c) Mucosal-associated lymphoid tissue and cutaneous associated lymphoid tissue	3
1.4	**Antigens** a) Immunogenicity versus Antigenicity, Factors that influence immunogenicity b) Epitopes– Properties of B cell epitopes and T cell epitopes c) Haptens - study of antigenicity, hapten-carrier conjugates	3
1.5	**Basic structure of Immunoglobulins & its functions** a) The role of multiple myeloma in understanding Ig structure b) Fine structure of Immunoglobulins– Immunoglobulin domains- variable region and constant region domains. c) Immunoglobulin classes– IgG, IgM, IgA, IgD and IgE; functions of Ig classes	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Immunoglobulin organization, B cell development and Major Histocompatibility Complex (MHC)**	
2.1	**Organization of immunoglobulins** a) Antigenic determinants on Immunoglobulins (Isotypes, Allotypes & Idiotypes) b) Effector functions of antibodies (ADCC, Complementation, opsonisation & Neutralization) c) Organization and expression of immunoglobulin light and heavy chain genes and antibody diversity	3
2.2	**B-cell activation & differentiation** a) B-cell activation and proliferation by Thymus Independent and Thymus Dependent antigens b) B-cell differentiation, class switching and generation of plasma cells and memory cells c) B-cell immunodeficiency disorders– X-linked agammaglobulinemia, selective immunoglobulin deficiency	3
2.3	**Antibody engineering & its applications** a) Polyclonal antibodies production & its applications (immunosupression & rabbit antithymocyte globulin) b) Monoclonal Antibodies Production c) Abzymes, immunotoxins & monoclonal imaging & its applications	3
2.4	**Major Histocompatibility Complex (MHC)** a) General organization and inheritance of MHC; MHC Haplotypes b) The structure of MHC class I and class II molecules c) Organization of MHC class I and class II genes, peptide binding of MHC molecules	3
2.5	**MHC immune responsiveness & HLA** a) Polymorphism of MHC class I and class II molecules; Cellular distribution of MHC molecules; MHC molecules and immune responsiveness and disease susceptibility b) Types of grafts; Mechanism of graft rejection; immunological basis of graft rejection; Graft versus host reactions, bone marrow & hematopoietic stem cell transplantation c) Human leukocyte antigen (HLA) typing by mixed lymphocyte reaction (MLR), microcytotoxicity tests and by PCR & Role of HLA typing in organ transplantation	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Cell-mediated Immune Responses**	
3.1	**Antigen presentation** a) Antigen processing by antigen presenting cells (endogenous antigens- cytosolic pathway; exogenous antigens endocytic pathway ; Presentation of Nonpeptide Antigens) b) Structure and functions of T cell receptors (TCR) c) TCR-peptide-MHC tri-molecular complexes	3

3.2	**Role of cytokine in immune responses** a) Cytokines– properties; cytokine antagonists b) Th1 and Th2 type of cytokines c) Delayed Type Hypersensitivity (DTH) and cytokines involved in DTH	3
3.3	**Cell- mediated cytotoxic responses** a) Cell-mediated immune response: General properties of effector T cells b) Direct cytotoxic response (cytotoxic T cells ,generation of effector CTLs, CTL mediated killing of target cells--Granzyme and Perforin Mediated Cytolysis& Fas-FasL Mediated Cytolysis) c) Experimental assessment of cell-mediated cytotoxicity- MLR, CML, GVH	3
3.4	**Autoimmunity & Immunodeficiency disorders** a) Auto-immunity– mechanisms and auto-immune diseases- Insulin Dependent Diabetes (IDDM); Rheumatoid Arthritis, Auto-immune Systemic lupus erythematosus (SLE) b) T cell primary immunodeficiency disorders– Severe combined immunodeficiency (SCID); c) Secondary immunodeficiency disorders- acquired immune deficiency syndrome (AIDS)	3
3.5	**Vaccines** a) Vaccines- Immunization(Passive& Active) b) Types of vaccines (Live, Attenuated; Inactivated or "Killed" vaccines; Subunit vaccines; Recombinant vector vaccines; DNA & conjugate vaccines) c) Adjuvants and its types	3

P**RACTICALS**

G302P- IMMUNOGENETICS

S.No	Topics to be covered
1	ABO blood typing
2	Micro-hemagglutination Test
3	Isolation of plasma
4	Isolation of serum
5	Serum protein Electrophoresis
6	Single Radial Immunodiffusion
7	Double diffusion
8	DOT ELISA
9	Western Blot by Enzyme-conjugated antibody
10.	Sandwich Enzyme Linked Immunosorbent Assay
11.	HLA typing by PCR
12.	Isolation of lymphocytes by histopaque
13	Cell-viability test by Trypan Blue
14.	MTT Assay
15.	Principle and procedure for enumeration of specific cell types by Fluorescent Activated Cell Sorter (FACS)

REFERENCE BOOKS

1. Essential Immunology– By I. Roitt, Publ: Blackwell
2. Immunology– By G. Reever& I. Todd, Publ: Blackwell
3. Immuno diagnostics– By S.C. Rastogi, Publ: New Age
4. Immunology: By Richard A. Golds, Thomas J Kindt, Barbaraa A. Osborne, Janis Kuby
5. Fundamental immunology– By William E.Paul.
6. Basic Immunology– By Bhoosreddy G.L. and Wadher B.J.
7. Text book of immunology– By Baruj Benacerraf

M.Sc. GENETICS
II YEAR SEMESTER- III
THEORY PAPER- III: ELECTIVE 1(A)
GE303T (1A): MEDICAL GENETICS

1. **Course Objectives (C.Obj)**
   a. To study the importance of genetic counseling and screening
   b. To learn molecular diagnostic methods
   c. To learn different approaches to therapy for genetic diseases

2. **Course Outcomes (C.O)**
   a. Apply skills to assess the risk of genetic diseases; Understand significance of prenatal genetic testing, new born screening and carrier screening in disease prevention.
   b. Acquaint with molecular diagnostic methods for different diseases.
   c. Imparts knowledge about therapeutic strategies for genetic diseases

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT-1	**Genetic counseling and screening for diseases**	
1.1	**Genetic disorders** a) Single gene disorders and molecular pathology b) Inborn errors of metabolism: Disorders of -carbohydrate metabolism, Amino acid metabolism, Purine and pyramidine metabolism, lipid metabolism c) Complex genetic disorders and Mitochondrial diseases	3
1.2	**Genetic testing:** a) Levels of genetic testing, Prenatal screening: Indications, Invasive and Non-invasive techniques; Detection of cytogenetic, biochemical and genetic defects in fetal samples b) Neonatal Screening: PKU, Galactosemia,Sickle Cell Anemia & Congenital hypothyroidism c) Heterozygote detection: Population based screening for Thalassaemias, Carrier screening in Cystic Fibrosis and DMD, Fragile– X syndrome, Genetic testing for Hemophilia	3
1.3	**Preclinical screening** a) Adult onset diseases -Alzheimer's, Huntingtons Disease & Familial hypercholesterolemia b) Disease susceptibility for complex diseases – Coronary Artery Disease & Type 2 Diabetes c) Molecular detection of known and unknown mutations in disease onset	2

1.4	**Pre-implantation genetic testing** a) Need for Preimplantation genetic testing and clinical applications b) Genetic profiling of embryos for screening of genetic defects, susceptibility and late-onset conditions c) Challenges, limitations and ethical concerns in PGT	2
1.5	**Genetic counseling and risk estimation** a) Prevention of genetic diseases b) Genetic counseling-importance, concerns c) Recurrence risk assessment under different modes of inheritance, Bayesian method of risk estimation	4

Unit Number	Topics to be covered	No. of lectures
UNIT-2	**Molecular diagnostics and prognosis**	
2.1	**Disease diagnosis** a) Molecular diagnostics: past, present and future b) Variant classification and detection methods c) Genomic data bases as tools for diagnostics, Emerging methods of diagnosis	3
2.2	**Markers for disease diagnosis and prognosis** a) Genetic markers and DNA based diagnosis b) RNA based diagnosis c) Protein/enzyme markers, Identification of biomarkers	3
2.3	**Molecular profiling-technologies** a) Genomic technologies: Whole genome sequencing, whole exome and targeted exome sequencing, designing of diagnostic panels b) Transcriptome analysis, Epigenome analysis, ChIP-Seq, Hi-C c) Metabolome profiling	2
2.4	**Cancer diagnostics** a) Detection of germ line and somatic variants b) Molecular stratification of tumors c) Molecular monitoring and prognosis	3
2.5	**Biosensors and nanoparticles for disease diagnosis** a) Types of Biosensors and their applications in diagnostics b) Nanomaterials- Types, classification and applications in disease diagnosis c) Challenges in clinical diagnostics	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Therapy for Genetic Diseases**	
3.1	**Conventional methods for treatment of genetic diseases**: a) Conventional therapies and need for gene therapy b) Diet replacement, dietary avoidance, protein/enzyme substitution; c) Recombinant gene products for therapy	2
3.2	**Gene therapy** a) Criteria for gene transfer- in vivo, in vitro & ex vivo strategies; b) Somatic cell gene therapy vs Germ line gene therapy; c) Gene transfer methods for therapy-Viral vectors, physical and chemical methods;	3
3.3	**Approaches for Gene therapy:** a) Gene Augmentation Therapy, b) Anti sense gene therapy, Gene editing of therapeutic genes c) Strategies for direct & Indirect cell killing	3
3.4	**Gene therapy: Success and failure** a) Gene therapy for Adenosine Deaminase deficiency, Familial a. Hypercholestrolemia, Cystic Fibrosis b) Gene therapy trials- current progress c) Limitations of gene therapy	2
3.5	**Advanced therapeutic strategies** a) Cancer Therapeutics, Identification of drug targets, Personalized therapy, Drug resistance mechanisms b) Immunotherapy-Approaches in immune therapy -use of Monoclonal antibodies, NK cells, Dendritic cells, B-lymphocytes and vaccines; Nanomedicine: Therapeutic applications of nanoparticles c) Pharmacogenomics in clinical care and drug discovery	4

PRACTICALS

GE 353 P (1A): MEDICAL GENETICS

S.No.	Topics to be covered
1.	Carrier testing by analysis of Trinucleotide repeat expansions; Heterozygote detection and screening for Thalassaemias/Hemophilia
2.	Presymptomatic screening for adult onset
3.	Maternal serum testing for prenatal diagnosis
4.	Problems on Genetic counseling
5.	Recurrence risk assessment by Bayesian method
6.	Dot blot assay/prick test for sickle cell anaemia-Neonatal testing
7.	Detection of BCR-ABL gene mutation in CML/ Molecular monitoring in cancer management
8.	Testing for phenylketonuria/Gauchers disease/ biochemical disease

REFERENCE BOOKS

1. Strachan & Read. Human Molecular Genetics, Wiley
2. Connor & Smith. Essentials of Medical Genetics, Blackwell
3. Emery & Mueller. Elements of Medical Genetics, ELBS
4. Maroni. Molecular and Genetic Analysis of Human Traits. Blackwell
5. Nussbaum et al. Genetics in Medicine, Saunders
6. Pasternak. An Introduction to Molecular Human Genetics, Fritzgerald
7. Edwin H. McConkey. Human Genetics: The Molecular Revolution, Jones & Bartlett publishers, Inc;
8. Vogel & Motulsky. Human Genetics, Springer
9. Sudbery. Human Molecular Genetics, Prentice-Hall
10. Hawley and Mori. The Human Genome, Academic

M.Sc. GENETICS-II YEAR
SEMESTER- III
THEORY PAPER- IV ELECTIVE 1 (B)
GE 303 T (1B): MOUSE GENETICS AND DISEASE MODELS

1. Course Objectives (C. Obj):

a. To understand the significance of mouse in human disease research.
b. To gain knowledge and understanding of mouse genetics.
c. To comprehend role of mouse in the production of models for human diseases and their applications.

2. Course Outcomes (C.O):

a. Acquire skills in manipulation of genes and genome in mouse for human disease understanding and treatment.
b. Acquaint with the methods used in knock-out and knock-in transgenic mouse models for human disease applications.
c. Apply husbandry and breeding skills for the production of mice in research and development.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Introduction to Mouse Genetics**	
1.1	a) History of mouse genetics b) Mouse as a model for human diseases c) Mouse genes, genome features and maps	3
1.2	a) Mouse strains – origin of modern classical strains b) Inbred strains & recombinant inbred strains c) Consomic and congenic strains	3
1.3	a) Mouse husbandry b) Facilities and sanitation procedures for mice c) Breeding of mice	3
1.4	a) Gene mapping b) Collaborative cross c) Breeding schemes for outbred populations - Diversity outbred	3
1.5	a) QTL mapping b) Fasting plasma glucose QTL c) Limitations of QTL mapping	3

nit Number	Topics to be covered	No. of lectures
UNIT II	**Mouse Embryology & Manipulation**	
2.1	a) Mouse early embryo development- Pluripotent stem cells b) Late embryonic development c) Cellular and molecular mechanisms controlling embryogenesis	3
2.2	a) Methods to study cell lineage in mouse embryos b) Mouse anatomy & histology c) Phylogenetic relationships of laboratory mouse	3
2.3	a) Methods of generating mouse models – non-targeted strategies b) Methods of generating mouse models – targeted strategies c) Transgenic mice - Florescence reporter genes	3
2.4	a) Conditional expression systems for transgenes b) Analysis of gene expression –lac Z reporter mouse lines c) Genome editing – generation of KI and KO mouse model via Easi-CRISPR	3

2.5	a) *In-vivo* mouse models in drug discovery b) Development of highly sensitive mouse strains for safety evaluation – applications c) Use of mouse models of human disease for non-clinical safety evaluation	3

Unit Number	Topics to be covered	No. of lectures
UNIT III	**Basic Mouse -Disease Models for Human Research**	
3.1	a) Using mouse to model human diseases b) Mouse genomics – structure of genome, annotation c) Humanized mice, Germ-free mice & Immunodeficient mice	3
3.2	o study oncogenes and tumor suppressor genes Mouse models of human cancer Mouse models of development- muscular, skeletal & cardiovascular systems	3
3.3	A) Mouse models for neurodegenerative diseases B) Mouse models of Alzheimer's disease C) Parkinson"s disease model – α-Synuclein mice	3
3.4	A) Multi-gene modified mouse model for complex human diseases B) Auto-immune disease mouse models C) Mouse models of infectious diseases	3
3.5	A) Modular design of human comorbidity mouse models B) Models of human diseases -genetic information database and biobank C) Mouse models for drug discovery	3

PRACTICALS:

GE303P (1B): MOUSE GENETICS & DISEASE MODELS

1. Housing, nutrition, husbandry & mice handling procedures.
2. Genetic monitoring of mouse inbred strain.
3. Mapping mendelian traits.
4. Mapping and identifying QTL.
5. Derive induced pluripotent stem cells from differentiated cells.
6. Analysis of gene function in embryonic mutants.
7. Analysis of gene function in adult mutants.
8. Study behavior traits.

SUGGESTED REFERENCES

1. Mouse Models of Human Canceredited by Eric C. Holland published by John Wiley & Sons, New Jersey 2004.
2. Mouse Models for Drug Discovery – Methods and Protocols edited by Gabriele Proetzel, Michael V. Wile published by Humana Press 2010.
3. Mouse Models of Developmental Genetic Disease edited by Robert S. Krauss published by Elsevier Inc. 2008.
4. The Laboratory Mouse by Hans Hedrich published by Elsevier Ltd. 2012.
5. Histological Atlas of the Laboratory Mouseby William D. Gude published by Springer science 2012
6. Transgenic Animal Technology: A Laboratory Handbookby Carl A. Pinkert published by Elsevier Inc. 2014.

M.Sc. GENETICS-II YEAR
SEMESTER- III
THEORY PAPER- IV ELECTIVE 2
GE 304 T (2A): PLANT GENOMICS & BIOTECHNOLOGY

1. Course Objectives (C. Obj)

a. To understand the plant genome organization and its applications in plant structural and functional genomics
b. To comprehend plant secondary metabolism and manipulate the plant cells
c. To know the manipulation features of the nuclear, chloroplast and mitochondrial plant genetic systems

2. Course Outcomes (C.O)

a. Apply the latest sequencing and bioinformatics analysis tools skill sets to the structural and functional genomics of plants
b. Acquire skills for manipulation through metabolic engineering of plant secondary metabolism in plant cell and organ cultures.
c. Gain skills in manipulation of plant genetic systems to generate transgenic plants for value addition.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Plant Genomics& Biotechnology applications**	
1.1	a) Plant nuclear genome- genome organization in plant nucleus b)Plant epigenome–epigenetic regulatory machinery of plants, RNA mediated gene silencing pathways, epigenome and plant development c)Plant organellar genomes- plastid and mitochondrial genomes	3
1.2	a)Plant genome sequencing – diversity of plant genomes b)Sequencing Technology - strategies for plant genome sequencing, high-throughputsequencing technologies: NGS, single molecule and real time sequencing:alignment programs, assembly, annotation,chromosome level assembly – haplotype resolved genomes, pan-genomes, c)Organellar genome sequencing – chloroplast genomes, plant mitochondrial genomes	3
1.3	a)Plant transcriptomics -RNAseq,sc-RNAseq, applicationsof transcriptome sequencing b) Plant proteomics- high throughput approach methods and principles– mass spectrometry-based proteomics, MALDI, applications. c) Plant metabolomics—principles, GC-MS, NMR analytical platforms, applications	3
1.4	a)Plant SNPs discovery and use in genotyping platform b)Genomic selection – training populations, phases of genomic selection, genomic estimated breeding value, c)Genomic selection - factors affecting genomic selection, approaches to improve genetic gain and genomic selection, applications	3
1.5	a) Genomic assisted breeding – genomic breeding, GWAS, HBB, PAGE/RAGE, speed breeding b)Applications of GAB - biotic and abiotic stress tolerance c) Plant genome editing and genome engineering- ZFN, TALENs, CRISPR-Cas9andODM	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Plant Secondary Metabolism& Plant Cell Biotechnology**	
2.1	a)Introduction to plant secondary metabolites- ecological functions & uses b) Terpenoids- synthesis of IPP, phenyltransferase and terpene synthase reactions,modification of terpenoid skeletons c)Alkaloids- biosynthesis	3
2.2	a)Phenolic biosynthesis- phenylpropanoid, phenylpropanoid-acetate pathways b)Lignans, flavonoids- biosynthesis c)Coumarins, stilbenes, styrylpyrones and arylpyrones	3
2.3	a)Plant metabolic engineering- approaches to metabolic engineering b)Phenolics & Alkaloid - metabolic engineering c)Terpenoids- metabolic engineering.	2
2.4	a)Plant cell culture- different plant tissue culture media, role of plant growthregulators in tissue culture b)Plant cell culture techniques- callus and cell suspension cultures; c)Plant secondary metabolites - strategies to improve secondary metabolite production in plant cell cultures - cell line selection, mediumoptimizations, optimization of couture environment, permeabilization, elicitation, nutrient feeding, precursor feeding, cell immobilization, biotransformation	3
2.5	a)Enhancement of secondary metabolites through organ cultures - Hairy root cultures, shootyteratomas b)Mass cultivation of plant cell and organ cultures- modes of bioreactor operations, differenttypes of bioreactors, hybrid reactors and disposable bioreactors c) Bioprocessing of plant cell cultures – bioreactor internal environment optimization and operation modes, downstream processing	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Transgenic plants in biotechnology**	
3.1	a) Plant nuclear transformation-Co-integrated vectors, binary vectors, types of promoters, reporter genes, novel andspecialized vectors for plant transformation. b)Transformants selection - Selectable markers (positive & negative selection), novel selection methods and restrictionenzymes to control T-DNA integration;. c)Transgenic plants - analysis oftransgenic plants. marker free transgenic technology	3
3.2	a)Gene introduction into chloroplast – approaches in chloroplast transformation b)Chloroplast transformation- advantages and disadvantages of chloroplast transformation; c)Tansplastomic plants - applications	3
3.3	a)Transgenic plants as bioreactors- advantages of transgenic plants as bioreactors, expression systems, sub-cellular targeting (protein targeting), optimization of plant production systems, plant expression hosts, downstream processing & purification b)Molecular farming for biopharmaceuticals - plantibodies, plantigens, therapeutic proteins& edible vaccines c)Molecular farming for industrial products - industrial enzymes,	3

	lysozyme, biopolymers, biofuel, paper manufacturing	
3.4	a) Plant mitochondrial genetic manipulation – advantage and limitations. b) Methods of mitochondrial transformation – microinjection, protoplast fusion, particle bombardment, Agrobacterium mediated transformation, c) Applications of mitochondrial genetic manipulation in crops.	3
3.5	a) Gene stacking – Multisite Gateway Cloning strategy b) Value addition with transgenic technology – improved shelf life, nutritional quality in fruits, improved quality of flower c) IPR and ethical issues of transgenic plants	3

PRACTICALS

GE354P (2A): PLANT GENOMICS & BIOTECHNOLOGY

S. No.	Topic to be covered
UNIT-1	
1	Genome browsers
2	TLC for screening of plant extracts/ extracting bioactive substances from plants
3	Preparation of different types of standard tissue culture media (MS and White's medium)
4	Induction of callus and initiation of cell suspension cultures
5	Cryopreservation/
6	Induction of hairy roots
7	Development of shooty teratomas

BOOKS RECOMMENDED

1. From Plant Genomics to Plant Biotechnology (2013) edited by PalmiroPoltronieri, Natalija Burbulis, Corrado Fogher, Woodhead Publishing Limited, New Delhi
2. Plant Genomics and Biotechnology (2016) Isabelle Nickel, Syrawood Publishing House
3. Plant Biotechnology and Agriculture: Prospects for the 21st Century (2012) edited by Arie Altman, Paul M. Hasegawa, Elsevier
4. Plant Cell Biotechnology by Rudolf Endress, Springer-Verlag Berlin
5. Molecular farming (2009) by Amita Sarkar, Discovery Publishing House Pvt. Ltd.
6. Metabolic Engineering of Plant Secondary Metabolism (2000) edited by Robert Verpoorte, A.Wilhelm Alfermann, Springer
7. Biochemistry and Molecular Biology of Plants (2015) edited by Bob B. Buchanan, Wilhelm Gruissem, Russell L. Jones, Wiley Blackwell

M.Sc. GENETICS-II YEAR
SEMESTER- III
THEORY PAPER-IV ELECTIVE-2B
GE 304T(2B): PLANT NUTRACEUTICALS AND NUTRIGENOMICS

1. **Course Objectives (C.Obj)**
   a. to comprehend the classification, biosynthesis of principal secondary metabolites and production of phytochemicals
   b. to know the role of nutrigenetics and nutrigenomics.
   c. to identify the significance of phytochemicals and nutraceuticals in health.

2. **Course Outcomes (C.O)**
   a. to apply plant cell biotechnology and produce phytochemicals.
   b. to comprehend and apply the role of polymorphism, biomarkers and microRNAs in nutrigenomics.
   c. to gain skills in using advanced tools and techniques in nutrigenomic analysis and develop functional foods and biofortification procedures.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Phytochemicals**	
1.1	a) Secondary metabolites and phytochemicals –function of secondary metabolic products in plants; b) Health benefits of phytochemicals; c) Phytochemical classes and chemical properties.	3
1.2	a) Biosynthetic pathways of secondary product classes –Terpenoid and shikimate pathways; b) Isoprenoid pathway; c) Polyketide pathway.	3
1.3	a) *In vitro* techniques for the cultivation of nutraceutical plants; b) Factors determining accumulation of secondary metabolites; c) Strategies to improve metabolite production, biological elicitors of plant secondary metabolites (mode of action and use in production of nutraceutics).	3
1.4	a) Phytochemicals in plant cell bioreactors –plant bioreactors; b) Hairy root culture for secondary metabolites production – *A. rhizogenes* transformed medicinal plants for metabolite production, bioreactors and hairy root culture; c). Commercial production of plant secondary metabolites.	3
1.5	a) Phytochemical extraction methods – maceration,percolation, decotion; b) Reflux extraction, pressurized liquid, pulsed electric field extraction; c) Liquid gas extraction, microwave assisted extraction, ultrasound assisted extraction.	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Nutrigenetics & Nutrigenomics**	
2.1	a) Nutritional genetics vs nutritional genomics; b) Nutrients modulating genome expression –nutrient as signal molecule, mechanisms of nutrient perception; c) Nutrigenetic diseases and Nutrigenomic diseases –PKU, obesity, CVD, cancer, inflammation, diabetes, osteoporosis.	3
2.2	a) Variation in human populations -gene polymorphism, SNP,	3

	nutritional implications; personalized nutrition; b) Biomarkers –biomarkers of biological effect -enzyme function, oxidative stress, immune function, bone health, cell turnover; biomarkers for genetic susceptibility; c) MicroRNAs as dietary bioactive compounds –characteristics, biogenesis and functions.	
2.3	a) Genetic selection- insertional inactivation and alpha complementation; b) Use of animal and cell models in nutrition and food research: in vitro models applicable in nutrigenomic studies; c) Use of animal models– advantages and limitations.	2
2.4	a) Transcriptomics- mRNA profiling, cDNA-AFLP, DNA microarrays, SAGE, MIAME/Nut; using transcriptomics to explain mechanism behind differences in response to diet. b) Proteomics-2D-DIGE, ELISA, protein microarray, MALDI-TOF, PSI (Proteomics Standard Initiative) –role of proteomics in nutrigenetics and nutrigenomics; c) Metabolomics-analytical tools–LC resolved and GC resolved mass spectrometry, NMR spectroscopy, global vs targeted metabolic profiling-applications to nutrition, metabolomics;	3
2.5	a) Bioinformatics–screening for bioactive nutrients and compounds; b) Genome annotation, gene prediction, DNA motifs; c) High throughput genomic screening –control of gene expression, methods of target validation (cell line testing, animal models) screening model.	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Health benefits of phytochemicals**	
3.1	a) Dietary phytopharmaceuticals- glucosinolates, carotenoids b) Phytochemicals used in traditional medicine; c) Resveratrol – applications.	3
3.2	a) Nutraceuticals - isoprenoid derivatives, phenolic compounds, carbohydrate derivatives, amino acid derivatives and minerals (Ca, Zn, Cu, K, Se); b) Nutraceuticals and antioxidant function-oxidative stress and ROS, antioxidants (amino acids, peptides and proteins), antioxidant defense systems; c) Phytochemical antioxidants in prevention and cure of chronic diseases.	3
3.3	a) Phytochemicals and cancer-models of carcinogenesis, cancer risk - nutrients and phytochemicals; impact on cancer metastasis suppressor genes, phytoestrogen; b) Phytochemicals in immune function-carotenoids and flavonoid; c) Plant lipids in health and disease; plant tochopherols/tocotrienols and health.	3
3.4	a) Functional foods in prevention of human health disorders-cancer prevention;	3

	b) Biofortification with phytochemicals; c) Dietary supplements – types, natural products.	
3.5	a) Probiotics – nutritional and health benefits; b) Prebiotics -sources, types, mechanisms and applications; c) Synbiotics- antioxidant properties, mechanisms and health benefits.	3

PRACTICALS

GE354P (2B): PLANT NUTRACEUTICALS AND NUTRIGENOMICS

1. Extraction and phytochemical screening of phytochemicals
2. Analysis of antioxidant capacity of phytochemicals and food plant
3. Chromatographic separation of phytochemicals
4. *In vitro* cultivation technique of nutraceutical plants- induction of callus and initiation of cell suspension cultures
5. Hairy root transformation for production of secondary metabolites.
6. Gene prediction & DNA motifs-Gene polymorphism-SNPs and gene expression analyses.
7. E*stimation* of *Resveratrol.*
8. GC-MS analysis of β-carotene.

BOOKS RECOMMENDED

1. Nutrigenetics and Nutrigenomics edited by Simopoulos and Ordovas, Karger
2. Phytochemicals of Nutraceutical Importance edited by DhanPrakash, Girish Sharma,CABInternational
3. Phytochemicals: Nutrient-Gene Interactions edited by MarkS. Meskin, Wayne R. Bidlack,R. Keith Randolph, CRC, Taylor & Francis
4. Functional Foods, Nutraceuticals and Degenerative Disease Prevention editedbyGopinadhanPaliyath, MaricaBakovic, KalidasShetty, Wiley-Blackwell
5. Nutrition and Immunology: Principles and Practice edited by M. Eric Gershwin, J.BruceGerman, Carl L. Keen, Springer.

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for year 2022-24)

M.Sc. GENETICS
II YEAR SEMESTER – IV

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G401T	Bioinformatics	3	4	30	70	100
2.	G402T	Applied Microbial Genetics	3	4	30	70	100
3.	GE403T	**ELECTIVE 3:** 3A. Cell and Tissue Engineering (or) 3B. Genetic Toxicology	3	4	30	70	100
4.	GE404T	Academic Research Project (Dissertation)	3	4			100
PRACTICALS							
1.	G451P	Genetic Engineering	2	4			50
2.	G452P	Applied Microbial Genetics	2	4			50
3.	GE453P	3A. Cell and Tissue Engineering (or) 3B. Genetic Toxicology	2	4			50
4.	GE454P	Academic Research Project (Viva-voce + Presentation)	2	4			50
		Total	**20**				**600**

M.Sc. GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
Scheme of Examination-Continuous Comprehensive Evaluation (CCE)
(Proposed for academic year 2023 onwards)

M.Sc. GENETICS
II YEAR SEMESTER – IV

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ Week	Marks						
					Internal Assessment					Semester Exam	Total
					I	II	III	IV	Attendance		
1.	G401T	Bioinformatics	3	4	10	10	10	10	10	50	100
2.	G402T	Applied Microbial Genetics	3	4	10	10	10	10	10	50	100
3.	GE403T	**ELECTIVE 3:** 3A. Cell and Tissue Engineering (or) 3B. Genetic Toxicology	3	4	10	10	10	10	10	50	100
4.	GE404T	Academic Research Project (Dissertation)	3	4	10	10	10	10	10	50	100
PRACTICALS											
1.	G451P	Genetic Engineering	2	4							50
2.	G452P	Applied Microbial Genetics	2	4							50
3.	GE453P	3A. Cell and Tissue Engineering (or) 3B. Genetic Toxicology	2	4							25
4.	GE454P	Academic Research Project (Viva-voce + Presentation)	2	4							25
		Total	**20**								**600**

M.Sc. GENETICS II YEAR
SEMESTER IV
THEORY PAPER-I
G401T: BIOINFORMATICS

Course Objectives:

a) To introduce basics of Bioinformatics and to explain the underlying basic principles of sequence analysis, and apply the same for analysing nucleic acid and protein sequences.
b) To provide an introduction to advanced areas such as sequencing, gene identification, genome wide analysis and drug discovery.
c) To impart an in depth understanding of proteomics and metabolomics.

Course Outcomes:

a) Enable to explore bioinformatics web portals, databases and tools.
b) Gains familiarity with sequence comparisons with algorithms and matrices. Able to perform various *insilico* analysis for gene structure and function prediction, target identification for drug designing
c) Gain insights to interpret the output from genomic, proteomic tools to use in agriculture and medical research.

Course Plan/Schedule:

Unit No	Topics to be covered	No. of Lectures
Unit-I	**Foundations of bioinformatics**	
1.1	a) Bioinformatics: A historical perspective b) aim and scope, sub-fields in bioinformatics c) Overview of bioinformatics applications.	3
1.2	a) Bioinformatics databases: what are databases, b) Importance of databases c) Classification of databases.	3
1.3	a) Types of databases: Nucleotide databases-Genbank, ENA, DDBJ b) Protein databases- Uniprtot, PDB, CATH, SCOP, metabolic pathway database - KEGG c) genome variation database- dbSNP, genome specific database -RAP-DB, MGD	3
1.4	a) File formats for data bases b) (Examples of file formats: genbank- DNA sequence, uniprot- protein sequence, PDB). c) Database search engines (Entrez and SRS)	3
1.5	a) Bioinformatics web portals : NCBI, EBI and Expasy b) Bioinformatics tools and resources - free online tools, downloadable free tools c) Software packages	3
Unit-II	**Sequence comparison methods**	
2.1	a) Basics of sequence alignment: match, mismatch, gaps. b) Scoring an alignment gap penalties (linear & affine gap penalties). c) Sequence relationships (sequence identity, similarity, homology, orthologs, paralogs & xenologs)	4
2.2	a) Pairwise alignment: Dot-matrix comparison of sequences b) Dynamic programming based pairwise alignment	3

	algorithms **c)** Global- Needleman and Wunch algorithm, local- Smith and Waterman algorithm.	
2.3	a) DNA vs Protein sequence alignment (permissible replacements, similarity score). b) Scoring matrices (PAM & BLOSUM) c) Heuristic algorithms for database searching (FASTA algorithm and BLAST algorithm)	2
2.4	a) Multiple-sequence alignment (MSA): significance of MSA b) Progressive and iterative based algorithms for multiple sequence alignment, consensus sequence c) Position specific scoring matrix (profile BLAST)	2
2.5	a) Phylogenetic analysis b) Distance matrix based tree construction c) UPGMA based tree construction	3
Unit-III	**Genomics, Proteomics and Metabolomics**	
3.1	a) Bioinformatics for genome sequencing b) First, next generation and third generation methods for DNA and RNA sequencing c) De-novo and reference based genome assembly (reads, Contigs, scaffolds), Transcript-profiling: Expression microarrays (gene array, oligoarray);	3
3.2	a) Genome annotation: Genome browsers, finding repeats b) Gene finding in prokaryotes and eukaryotes c) Finding promoters and regulatory motifs	3
3.3	a) Protein classification: Scop and CATH schemes of classification (motifs, domains, folds, class, architecture, family & super family) b) Protein profiling – 2D gel electrophoresis c) protein fingerprinting & identification	3
3.4	a) Structural bioinformatics: Secondary structure prediction, tertiary structure prediction (homology modelling) b) 3D structure evaluation. c) Metabolic networks: Metabolic pathways and reconstruction	3
3.5	a) Medical & Agricultural application of bioinformatics b) Understanding diseases and identification of disease causing genes c) Overview of drug discovery and pharmacogenomics	3

G401 P: BIOINFORMATICS PRACTICALS

UNIT-1	Data Retrieval & Sequence analysis
1	Understanding DNA/protein coding systems: a) Download and install Bioedit.
2	Bioinformatics web portals a) NCBI b) EBI c) Expasy
3	Databases a) Explore and download nucleotide sequences from Genbank and ENA databases b) Explore gene databases (entrez gene, gene cards) c) Explore and download protein sequence from Uniprot database
4	File formats a) Genbank, ENA, FASTA, PDB, FastQ, BAM) b) Sequence format conversion using Readseq tool
5	Pairwise alignment of DNA and protein sequences a) Dot matrix comparison of sequences using graphs and dot matcher tool b) Global alignment- Emboss Needle c) Local alignment- Emboss Water
6	Database search tools a) FASTA b) BLAST
7.	Multiple sequence alignment of DNA and protein sequences a) Clustal Omega
UNIT-2	**Genomics and Proteomics**
8.	Genome browsers and databases a) UCSC genome browser b) Genome specific databases : RAP-DB, MGD c) Genome variation database – dbSNP
9.	Prediction of genes in prokaryotic and eukaryotic genomes a) ORF Finder b) Genscan c) Glimmer
10.	Prediction of SSRs in DNA sequence (SSRit)
11.	Translation of a nucleotide (DNA/RNA) sequence to a protein sequence using Translate tool
12.	Structure databases a) Explore and download protein structures from PDB b) Explore and download protein structures from MMDB
13	Compute physical and chemical parameters of protein using Protparam tool
14	Prediction of secondary structures of proteins a) Chou fasman method b) GOR IV method c) Psipred
15	Tertiary structure prediction by homology model building

REFERENCE BOOKS

1. Introduction to bioinformatics by Aurther M lesk
2. Developing informatics computer skills by Cynthia Gibas, Per Jambeck
3. Chemoinformatics: a textbook by Johann Gasteiger
4. Bioinformatics second edition by David M mount
5. Essential bioinformatics by Jin Xiong
6. Bioinformatics computing by Bryan Bergeron
7. Bioinformatics: Concepts, skills & applications by R.S. Rastogi
8. Bioinformatics: methods and applications genomics, proteomics and drug discovery by S.C. Rastogi, Parag Rastogi, Namita Mendiratta
9. Bioinformatics and functional genomics (third edition) by Jonathan Pevsner
10. Data mining in Bioinformatics, Jason T. L Wang, Zaki, Toivonen and Dennis Shasha

M.Sc. GENETICS-II YEAR
SEMESTER- IV
THEORY PAPER- II
G402T-APPLIED MICROBIAL GENETICS

1. Course Objectives (C. Obj)

a. To understand the genetic mechanisms of infection characteristics in pathogens providing the clinical behavior of the microorganisms
b. To understand the application of microbe and microbiomes genetics and genomics for sustainable agriculture
c. To comprehend the role of microorganisms and genetically engineered microorganisms in industrial and environmental biotechnology.

2. Course Outcomes (C.O)

a. Gain skills in genetics of pathogenesis, diagnosis and develop control strategies for infectious diseases
b. Apply and analyze the microbes and microbiomes genetics for sustainable agriculture
c. Evaluate and produce genetically modified microorganisms of industrial relevance and environmental remediation

Course Plan/Schedule

Unit No	Topics to be covered	No. of lectures
Unit 1	**Medical applications**	
1.1	a) Bacteria – structure and classification; bacterial genetics of antimicrobial resistance– genetic linkage of antimicrobial resistance, plasmid addiction systems, adaptive mutations in chromosome genes. b) Bacterial pathogenesis – host susceptibility, pathogenic mechanisms, specific virulence factors, endotoxins c) *Vibrio cholera* -etiology, epidemiology, pathophysiology, clinical manifestations, antigenic types -O1, O139, host defenses, diagnosis, control	3
1.2	a) Viruses – structure, classification and multiplication; viral genetics -mutations, recombination, reassortment,complementation, phenotypic mixing b)Viral pathogenesis – cellular pathogenesis, tissue tropism c)HIV – life cycle, characteristics, epidemiology, detection, host genetic determinants	3
1.3	a) Fungi – structure and classification; biology of fungi - reproduction b) Disease mechanisms of fungi – host factors, fungal factors c) *Candida albicans* -pathogenicity, polymorphism, virulence factors, candidiasis	3
1.4	a) Protozoa – structure, classification and life cycle stages; pathogenesis and defenses b) Hemoflagellates – American Trypanosomiasis, African Trypanosomiasis; population genetics of *Trypanosoma brucei* *c)*Algae – structure and classification; life cycle -*Chlamydomonas*	2

	reinhardtii as a human genetics model system, tetrad analysis, zygote plating	
1.5	a) Emerging & re-emerging infectious diseases- epidemiology- acuterespiratory diseases b)Molecular diagnosis of pathogens- methods and applications c)Recombinant vaccine strategies- recombinant vaccines using bacterial or viral vectors; novel vaccines - mini cells, vaccinia virus recombinants, synthetic peptide vaccines,subunit vaccines (recombinant subunit vaccine- Hepatitis B vaccine, ViCPS vaccine),DNA vaccines, reverse vaccinology	3

Unit No	Topics to be covered	No. of lectures
UNIT 2	**Agriculture applications**	
2.1	a) Plant-microbeinteractions–beneficial role of microorganisms decomposition, mycorrhizae, nitrogen fixation, rhizosphere b) Plant-microbe interactions tools- GWAS, Metagenomics, metatranscriptomics c) Beneficial plant-microbe interactions under abiotic and biotic stress	3
2.2	a) Microbe assisted crop improvement – mechanisms and applications of PGPR b)Microbe assisted crop improvement – mechanisms and applications of PSB c) Microbial Biofertilizers -microorganisms used in the production of biofertilizers, formulation of biofertilizers	3
2.3	a) Microbe assisted crop improvement- microbial control of pests, bio-control agents/microbial pesticides b)Microbe assisted crop improvement -microbial control of weeds, microbial herbicides c) Microbe assisted crop improvement – microbial controls of pathogens by microbial biological control agents, mode of action	3
2.4	a) Microbial applications for improving nutrition – microbial based plant nutrient acquisition b)Microbial biostimulants -composition, role and application c) Soil renovation – enhancement of soil characteristics, using omics to assess soil microbial diversity, targeted and untargeted approaches to manage soil microbial diversity	3
2.5	a) Microbe assisted phytoremediation –strategies to improve phyto stabilization and phytoextraction, genetic engineering, microbe-assisted and chelate-assisted approaches b) Climate change – role of microorganisms to mitigate climate change impacts c)Phyllosphere and spermosphere – role of microbial communities in plant health and development	3

Unit No	Topics to be covered	No. of lectures
Unit 3	**Industrial and Environmental Applications**	
3.1	a) Isolation and screening of industrial microorganisms –methods of isolation, primary and secondary screening. b)Genetic improvement of strains for biotechnological purposes- Strategies for strainimprovement, mutation & selection, natural gene transfer methods, conventional breeding, protoplast fusion, in vitrorecombinant DNA technology c) Genetic improvement of processes for higher productive microbial strains– genome-based reconstruction, metabolic engineering (omics, association analysis, massive parallel signature sequencing) directed evolution, molecular breeding (DNA shuffling, whole genome shuffling), combinatorial biosynthesis.	3
3.2	a) Microbial enzymes – tools to search new enzymes (microbial genomes, metagenomic screening, extremophiles) b) Applications of microbial genetics in enzyme technology, improving efficiency of enzyme production, generation of novel enzymes- strategies, site-directed mutagenesis, directed evolution, antibody catalysis, computational redesign, *de novo* methods c)Enzyme bio-catalysis applications – detergent additives, textile industry, pulp industry, feed industry, food processing, chemical industry, pharmaceutical industry.	3
3.3	a) Microorganisms in biofuel production – ethanol production, microbial fuel cells, microbial based fatty acids for biodiesel, microbial communities in feedstock production b)Bioprospecting of microbial strains for biofuel production c) Genetic engineering of microorganisms for biodiesel production	3
3.4	a) Monitoring pollutants – whole cell biosensors, whole cell arrays. b) Engineering microbes for bioremediation– microbes as tool for bioremediation, mechanisms of pollution degradation – approaches used to modify microbes c)Environmental hazards of genetically engineered microorganisms – risk assessment	3
3.5	a) Biomining- engineering microbial consortia, communication in natural and engineered consortia, acid rock drainage b) Oil recovery – genetic engineering of microorganisms for enhanced oil recovery and treatment c) Mineral leaching and recovery – microbial leaching, genetics in strain improvement, metal recovery.	3

PRACTICALS
G452P: APPLIED MICROBIAL GENETICS

S. No.	Topic to be covered
UNIT-1	
1	Preparation of media
2	Enumeration of microbes
3	Staining techniques for microbe identification
4	Examination of pathogenic bacterial, fungal & protozoan types
5	Cultivation of clinically significant hemoflagellates
6	PCR detection of microbial pathogen
7	Plasmid profile analysis
UNIT-2	
8	Induction of mutations in bacteria
9	Replica plating for isolation of auxotrophic mutants
10	Identification of different genera of VA mycorrhizal fungi
11	Culturing nitrogen fixing bacteria from root nodules of leguminous plants
12	Lyophilization
13	Biofilm formation in glass tubes
14	Spectrometric analysis of bioremediation
15	Gene expression analysis using reporter gene assay

BOOKS RECOMMENDED

1. Microbial Genetics Applied to Biotechnology by Venetia A. Saunders, Springer
2. Primary Care: A Collaborative Practice by Terry Mahan Buttaro, Elsevier
3. Microbiology: A Clinical Approach, second edition (2015), Anthony Strelakauskas, Angela Edwards, Beatrix Fahnert, Garland Science
4. Principles of Plant-Microbe Interactions–Microbes for Sustainable Agriculture (2015) Editor Ben Lugtenberg, Springer
5. Medical Microbiology Seventh Edition (2013) Murray, Rosenthal, Pfaller; Elsevier, Saunders
6. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) by Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattern. ASM Press

M.Sc. GENETICS II YEAR
SEMESTER IV
THEORY PAPER-III (ELECTIVE-3)
G 403 T (3A): CELL AND TISSUE ENGINEERING

1. Course Objectives (C. Obj)

a. To give the basics of cell interactions and tissue architecture
b. To enable basic understanding of tissue engineering and impart knowledge about biomaterials and scaffolds for tissue engineering
c. To provide insights into practical approaches and applications of tissue engineering

2. Course Outcomes (C.O)

a. Understanding of basic concepts of cell architecture and its interactions
b. Comprehension of different models of tissue engineering and lab reactors
c. Gain knowledge regarding the factors that determine the success of tissue engineering and learn various applications of tissue engineering

Unit No	Topics to be covered	No. of lectures
Unit 1	**Cell differentiation, tissue development and cell culture**	
1.1	a) Basics of growth and differentiation in animal cell-cell structure and function of organelles,, cell determination & differentiation, tissue organization, tissue components, tissue types b) Dynamic states of tissues, homeostasis in highly prolific tissues & tissue repair and regeneration, matrix molecules & ligands, c) Cell- ECM interactions, malfunctions in ECM signaling, cell junctions in tissues, angiogenesis	3
1.2	a) Measurement of cell characteristics - cell number and viability, cell-fate processes (cell proliferation, differentiation, embryonic cellular movement and programmed cell death), cytoskeleton and cell motility (microtubules, intermediate filaments, microfilament, cilia and flagella), cell function b) Response to mechanical stimuli, inductive phenomena (instructive and permissive) c) Embryonic morphogenesis & regeneration	3
1.3	a) Establishment of cell culture - cells expansion and characterization- cell signaling molecules, growth factors, hormone and growth factor signaling; cell transfer and storage- cell attachment, differential cell adhesion, receptor ligand binding and cell surface markers b) Animal cell culture (culture media and role of serum in cell culture, culture environment & cell separation, maintenance of cells *in vitro* and subculturing, primary cells vs. cell lines) c) Cryopreservation and reconstitution of cell lines	3
1.4	a) Interaction between cells and their environment,	3

	biological testing of biomaterials for tissue engineering application b) Cell-polymer interactions, effects of matrix on cell growth, considerations for the design of artificial organs c) Cell interactions with polymers in suspension, cell interactions with three-dimensional polymer scaffolds and gels	
1.5	a) Three dimensional cell culture: Organ, organotypic and histiotypic culture, collagen gel model b) Factors influencing transplantation of engineered tissues and organs, Graft rejection (Leucoderma, Burns, & Liver cirrhosis), Fetal tissue engineering and cell as therapeutic agent c) Tissue engineering bioreactors — classification and design	3
Unit 2	**Cells & biomaterials for tissue engineering**	
2.1	a) Stem cells – types; embryonic stem cells, adult stem cells b) Induced pluripotent stem cells, Perinatal stem cells) c) characteristics and properties (totipotency & pluripotency)	3
2.2	a) Morphogens-Biology of tissue morphogenesis; Morphogens as bioactive signaling molecules during morphogenesis; b) ECM & morphogens in tissue morphogenesis; c) Morphogens as signaling cues in tissue engineering	3
2.3	a) Biomaterials for tissue engineering- Biodegradable polymer selection criteria; b) Biologically derived polymers- Peptides and proteins (collagen, silk) polysaccharides (Cellulose, Glycosaminoglycans), and synthetic materials– polymers (PGA, PLA , and theircopolymers); c) Biomimitics	3
2.4	a) Biofabrication technologies: Electrospinning, Inkjet three-dimensional bioprinting, Extrusion three-dimensional bioprinting, Laser-assisted bioprinting,Stereolithography, Open-sourced 3DP b) Biomaterials as bioinks for three-dimensional bioprinting: Hydrogel-based bioinks -properties, Synthetic hydrogels, Naturally derived hydrogels & Tissue-specific extracellular matrix based hydrogels; c) Scaffold-free cell printing;	3
2.5	a) Three-dimensional scaffolds: 3D scaffold design and engineering, Mass transport and pore architectures, Mechanics, Electrical conductivity, b) Three-dimensional scaffolds:Surface properties, Temporal control, Spatial control;	3

	c) Tissue engineering triad	
Unit 3	**Tissue engineering of organs, its regulatory and ethical issues**	
3.1	a) Musculoskeletal tissue engineering-overview b) Bone tissue engineering: composition, & functions; Biomaterials,Cell sources &growth factors for Bone tissue engineering c) Cartilage tissue engineering: composition, types of cartilage & functions; Biomaterials, Cell sources & growth factors for cartilage tissue engineering	3
3.2	a) Soft tissue engineering- skin:Structure and functions of skin, b) Tissue-engineered therapy with stem cells, bioactives, and biomaterials; c) Bioengineered skin (Apligraf & Dermagraft)	3
3.3	a) Hepatic tissue engineering-Liver architecture and function b) Biomaterials andCell sourcesfor liver tissue engineering c) growth factors for liver tissue engineering	3
3.4	a) Regeneration of cornea-Corneal anatomy and functions; b) Therapeuticapproaches for different corneal cell types: c) epithelial tissue engineering, stromal tissue engineering and endothelial tissue engineering,	3
3.5	a) Tissue engineering- Current challenges; Future directions: Smart biomaterials, Cell sources, Whole organ engineering, advances in Biofabrication technologies, Tissue neovascularization etc. b) Regulatory issues: Regulatory background-FDA, Tissue-engineered and regenerative medicine products-regulatory challenges, regulation of HCT/Ps, Responsibilities of sponsors and investigators, c) Ethical issues pertaining to genetic privacy, ownership, religious faiths, therapeutic vs cosmetic use, nature of identity. Policies, etc	3

PRACTICALS
GE453 P (3A): CELL AND TISSUE ENGINEERING

S. No.	Topics to be covered
1	Tissue culture basics-Sterilization of Tissue culture components,
2	Preparation of tissue culture media RPM1-1640/MEM/DMEM,
3	Filtration of tissue culture media
4	Tissue culture/ Cell culture maintenance- Maintenance of tissue culture, Sub culturing (Trypsinization, Passaging & Seeding)
5	Handling of suspension cultures
6.	Freezing of cells
7	Cell counting – Counting cells on heamocytometer
8	Isolation of stem cells
9	Trypan blue exclusion test
10	Cell Viability assay- MTT assay to determine the metabolic activity of cell
11	PI staining and cell cycle analysis by Flow cytometry
12	Cell invasion and migration assay- Cell culture wound closure assay
13	Colony formation assay
14	Spheroid formation assay
15	Preparation of natural scaffolds

REFERENCE BOOKS

1. Principles of tissue engineering- Robert.P.Lanza, Robert Langer & William L.Chick, academic press
2. The biomedical engineering –Handbook, Joseph D. Bronzino, CRC press
3. Introduction to biomedical Engg. - Endarle, Blanchard & Bronzino, academic press
4. Tissue engineering- B. Palsson, J.A.Hubbell, R.Plonsey & J.D.Bronzino, CRC-Taylor & Francis.

M.Sc. GENETICS-II YEAR
SEMESTER- IV
THEORY PAPER-III ELECTIVE-3
GE403T (3B): GENETIC TOXICOLOGY

3. Course Objectives (C.Obj)

a. To know the mechanisms of genetic toxicology.

b. To gain knowledge on the methods of evaluation of genotoxicity utilizing mammalian, non-mammalian, cell based and novel assays.

d. To comprehend the methods of evaluation of genotoxicity utilizing plant systems and omics approaches**.**

4. Course Outcomes (C.O)

a. To apply mechanisms of mutagenesis and carcinogenesis for environmental and human health monitoring.

b. To acquaint with skills necessary for conducting genotoxicity assays using different systems.

c. To collect and analyze samples for genotoxic effects.

Course Plan/Schedule

Unit No	Topics to be covered	No. of lectures
Unit 1	**Introduction to Genetic Toxicology**	
1.1	(a) History of genetic toxicology- components of genetic toxicology; (b) Scope of genetic toxicology; (c) Significance of genetic toxicology- role of genetic toxicology in health effect testing.	3
1.2	(a) Cell cycle and chromosome mechanics in somatic and germ cells somatic vs germ cells; (b) Chromosome; (c)Mitotic cell cycle, meiosis &chromosome mechanics.	3
1.3	(a) DNA damage and repair- post-replication repair, excision repair, base replacement, deletions and insertions; (b) Mutagenesis- single nucleotide, point mutations, intercalating frame shift mutagens, cross linking, mutagens, clastogenic mutagens; (c) DNA repair and apoptosis – consequences of DNA damage.	3
1.4	(a) Carcinogenesis-classification of carcinogens: physical, chemical and biological agents; (b) Mechanisms of carcinogenesis- oncogenes or tumor suppressor genes; (c) Chromosomal abnormalities leading to cancer- epigenetic carcinogens.	3
1.5	(a) Consequence of genotoxic effects in humans and other mammals- gene pool consequences; (b)Relationship of genotoxic effect to other toxicologicphenomena; (c)Applications of genetic toxicology- human & environment monitoring.	3

Unit No	Topics to be covered	No. of lectures
Unit 2	**Evaluation of genotoxicity -I**	
2.1	a) *In vitro* gene mutation – bacterial reverse mutation assay (Ames test), mammalian cell Hprt mutation; b) *In vivo* gene mutation – Rodent lymphocyte Hprt mutation assay, mouse spot test, mouse specific locus test, transgenic rodent gene mutation assay (somatic & germ cells); c) *In vitro* gene mutation & chromosome mutation – mouse lymphoma forward mutation assay (L5178Y/Tk+/-), Tk gene mutation assay.	3
2.2	a) *In vitro* clastogenicity – mammalian chromosomal aberration assay; b) *In vitro* clastogenicity and aneugenicity – rodent micronucleus assay (bone marrow & peripheral blood), micronucleus assay (human lymphocytes); c) *In vivo* clastogenicity (germ cell) – rodent dominant lethal test, mouse heritable translocation assay.	3
2.3	a) Chromosome aberration (germ cells)– mammalian spermatogonial chromosome aberration test; b) *In vivo* chromosomal aberration tests-rodent bone marrow chromosomal effects; c) *In vitro/In vivo* DNA strand break– comet assay, alkaline elution assay; *In vitro/In vivo* DNA repair – UDS assay, UDS assay in hepatocytes.	2
2.4	a) *In vitro*/In vivo DNA damage – Sister chromatid exchange in mammalian cells; b) *In vitro* DNA adducts – DNA adduct analysis; c) Gene mutation in mammalian cells in culture – CHO HGPRT gene mutation assay,	3
2.5	a) Gene mutation in mammalian cells in culture - V79 HGPRT gene mutation assay, AS52/Xprt mutation assay in Chinese hamster cell. b)Gene mutation in *Saccharomyces cerevisiae*; c)*In vitro* cytogenetic assay – mitotic recombination in Saccharomyces cerevisiae.	3

Unit No	Topics to be covered	No. of lectures
Unit 3	**Evaluation of genotoxicity –II**	
3.1	a)*In vivo* cytogenetic assay – drosophila sex-linked recessive	3

	lethal test; b) Genome mutation assays –specific locus test in Neurospora. c)Mammalian cell transformation (in vitro carcinogenesis)– BALB/c-3T3 cells, C3H10T1/2 cells;	
3.2	a) Novel assays– gamma-H2AX, GADD45a-GFP Green Screen; b) Biomarkers– application of biomarkers for human risk assessment c) Nongenotoxic carcinogen mechanisms – kidney cancer in male rats & alpha-2 microglobulin nephropathy, mouse liver tumors, peroxisome proliferation, dioxin & aryl hydrocarbon receptor	3
3.3	a) Carcinogens in plants– mycotic toxins, mushroom toxins, streptomyces toxins; b) Genotoxicity & carcinogenicity of herbal products – volatile alkenyl benzenes, anthraquinones c) Genotoxic agents in agro-ecosystem– mutagenicity and carcinogenicity of pesticides	3
3.4	a) Plant dependent mutation assays - higher plant genetic systems for screening & monitoring mutagens b) Transgenic plants for environmental pollution genotoxicity – transgenic systems, marker genes used for mutation assay c) Molecular techniques – TUNEL test, flow cytometry.	3
3.5	a) *In silico* approaches– QASR computational toxicology, Ab initio molecular models for genotoxicity b) Toxicogenomics– high throughput screening of genotoxicity- ToxTracker assay c) Genetic toxicology in drug discovery and optimization – high-throughput screening	3

PRACTICALS
GE453P (3B): GENETIC TOXICOLOGY

UNIT-I

1. Comet assay
2. Bacterial reverse mutation assay
3. In vitro micronucleus test
4. Chromosomal aberration test
5. Sister chromatid exchange assay
6. SLRL
7. In silico genetic toxicology analysis
8. *Allium* chromosome aberration test

UNIT -II

1. Detection of oncogenic mutation.
2. Detection of programmed cell death.
3. Genotoxic testing of environmental chemicals.
4. Analysis of genotoxic impurities in pharmaceuticals.
5. Carcinogenicity predictive software
6. Genotoxicity predictive software
7. Assessment of cancer – bioinformatics of genomics.

BOOKS RECOMMENDED

1. Principles of Genetic Toxicology (2013) by D. Brusick Second Edition, Springer.
2. Genetic Toxicology Testing -A Laboratory Manual edited (2016) by Ray Proudlock Elsevier Academic
Press.
3. Genetic Toxicology: An Agricultural Perspective (2013) edited by Raymond F. Fleck, Springer US.
4. Transgenic plants as sensors of environmental pollution genotoxicity (2008) Kovachuk and Kovalchuk.Sensors 8(3), 1539-1558.
5. Toxicology of Herbal Products (2017) edited by OlaviPelkonen, Pierre Duez,PiaMaaritVuorela,HeikkiVuorela, Springer International Publishing.
6. Genetic Toxicology - Principles and Methods (2012) byJames M. Parry, Elizabeth M. Parry, Humana Press.
7. Insight on Genotoxicity (2020) by Shiv Shankar Shukla, Ravindra Kumar Pandey, Bina Gidwani, Gunjan Kalyani, CRC Press.