MSc GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for academic year 2019 onwards)

MSc 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	4	4	20	80	100
2.	G102T	Cell Biology &Cytogenetics	4	4	20	80	100
3.	G103T	Fundamentals ofBiochemistry	4	4	20	80	100
4.	G104T	Biostatistics and Population Genetics	4	4	20	80	100
PRACTICALS							
1.	G151P	Principles of Inheritance	2	4		50	50
2.	G152P	Cell Biology &Cytogenetics	2	4		50	50
3.	G153P	Fundamentals of Biochemistry	2	4		50	50
4.	G154P	Biostatistics and Population Genetics	2	4		50	50
		Total	**24**	**32**			**600**

MSc 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 comprehend the sex determination mechanisms, sex linked inheritance and patterns of Non-Mendelian inheritance
d. To analyze the linkage and mapping of genes in eukaryotic systems

2. Course Outcomes (C.O)

a. Student is able to comprehend and apply the Mendelian inheritance in humans, plants and animals
b. Student gains the use and handling of model organisms in research studies
c. Student relates the patterns of sex-linked, sex determination and Non-Mendelian inheritance in humans, plants and animals
d. Student is able to solve and analyze the linkage analysis of genes in eukaryotic organisms

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Mendelian Inheritance**	
1.1	Mendel's Laws of Inheritance- Monohybrid cross, principle of segregation, dihybrid cross, principle of independent assortment, trihybrid cross, cellular and molecular basis of Mendelian inheritance, Probability in prediction and analysis of genetic data, evaluating the fit of observed results to theoretical expectations (chi-square method)	3
1.2	Pedigree analysis - Segregation in human pedigrees, autosomal inheritance in humans, pedigree analysis of autosomal disorders, probability in pedigree analysis	2
1.3	Extensions to Mendelian Inheritance (Allelic Interactions)- codominance, incomplete dominance, pleotropism, lethals and sublethals, multiple alleles, (white eye locus in Drosophila, ABO blood group alleles in human, Rh factor alleles in man, self-incompatibility alleles in plants), segregation distortion	3
1.4	Extensions to Mendelian Inheritance (Non-allelic Interactions)- Epistasis, mechanism of epistasis – complementary genes, supplementary genes, recessive and dominant epistatic genes, inhibitory genes, duplicate genes, polymeric genes	3
1.5	Polygenic Inheritance- transgressive segregation, kernel color in wheat, skin color in man, height in man, human eye color, multifactor hypothesis, gene effects (additive, dominance, over-dominance and epistasis) - QTL	3
1.6	Genes to phenotype- Inborn errors of metabolism, one-gene one-enzyme hypothesis, complementation, position effect variegation(eye color in Drosophila)	2

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Eukaryotic Model Systems for Genetic Analysis**	
2.1	Life cycle and importance of Drosophila- Drosophila genome, polytene chromosomes, balancer chromosomes, morphs, fly resources	3
2.2	Life cycle and importance of Neurospora, sexual cycle, genome features	2
2.3	Life cycle and importance of Yeast, Genome features, scope and limitations as model organism	2
2.4	Life cycle and importance of *C.elegans*- genetics, growth and maintenance, sexual forms and their importance, genome and resources	2
2.5	Life cycle and importance of Zebra fish, useful features of zebra fish, zebra fish as model system for human diseases	2
2.6	Life cycle and importance of Arabidopsis –reasons for adoption, genome, genetic resources	2
2.7	Life cycle and importance of Mouse- Mouse as a model for human genetic diseases	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Sex determination, Sex-linked Inheritance and Extra-nuclear inheritance**	
3.1	Genetic basis of sex determination in *Drosophila*, *S. alba*, Man; Environmental effects in *Bonellia*, Lizards	2
3.2	Sex-linked Inheritance- X and Y-linkage-red and white eye colour in *Drosophila, haemophilia* and colour blindness in man. Sex limited and sex influenced traits	2
3.3	Non-Mendelian Inheritance– Leaf variegation of higher plants, Corren's studies in *Mirabilis jalapa,* Maternal inheritance-Poky in*Neurospora*-Heterokaryon test, Maternal influence- shell coiling insnails Inheritance of *iojap* in *Zea mays*	3
3.4	Non-Mendelian Inheritance in man - hereditary diseases	2
3.5	Uniparental Inheritance - Extra nuclear genes in Chlamydomonas, Mutants showing uniparental inheritance,	2
3.6	Extra nuclear genes in Baker's Yeast Petite mutants, Genetic mapping of mitochondrial Genes in yeast	2
3.7	Significance of cytoplasmic inheritance - possible origins of chloroplast and mitochondrial genomes	3

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Linkage and Gene Mapping in Eukaryotes**	
4.1	Cytological basis and evidence of crossing over- Stern experiments in Drosophila, Creighton and McClintock experiment in maize	3
4.2	Concept of linkage –Linkage groups, phases of linkage, coupling and repulsion phase, meiotic recombination, recombination frequency and genetic distance	3
4.3	Construction of genetic maps In Drosophila and maize using two point and three point test crosses with emphasis on interference and coefficient of coincidence	3
4.4	Tetrad analysis and gene mapping in Neurospora	2
4.5	Gene mapping with unordered tetrads in yeast	2
4.6	Cytological mapping – Zeste-White locus mapping in Drosophila	2

PRACTICALS

G151P: PRINCIPLES OF INHERITANCE

S. No.	Topic to be covered
1	Life cycle of Drosophila, Maintenance of stocks and Identification of mutants
2	Life cycle of maize and Segregation analysis in maize cobs
3	Using Chi-square test on Mendelian ratios
4	Segregation analysis in Drosophila
5	Application of chi square test to gene interaction ratios
6	Mapping by Tetrad analysis
7	Gene mapping from three point test crosses
8	Autosomal inheritance in humans & pedigree analysis of autosomal disorders
9	Segregation in human pedigrees
10	Sex determination in maize

REFERENCE BOOKS

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 ABrown Edition:1st Garland Science Taylor & Francis Group ISBN: 9780815365099
4. Concepts of Genetics by William S. Klug, Michael R. Cummings, Charlotte A. Spencer2005 Benjamin-Cummings Publishing Company ISBN 0131918338 (ISBN13: 9780131918337)
5. Genetic Analysis: An Integrated Approach by Mark Frederick Sanders, John L. Bowman 2014 2nd edition ISBN: 0321948904/ ISBN-13: 9780321948908**.**
6. Drosophila: A Laboratory Handbook 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.

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

2. Course Outcomes (C.O)

a. The students learn the structure and functions of the organelles and cytoskeleton
b. The students learn the phases of the cell cycle, check points, mitosis & meiosis in detail and further know about the stimulus and cell death mechanisms
c. Gain an insight about chromatin organization so as to apply the knowledge for understanding epigenetics.
d. 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	**Organization of The Eukaryotic Cell**	
1.1	Microscopic techniques and applications: Light microscope, Phase contrast microscope, Fluorescent, Confocal microscope and Electron microscopes	3
1.2	Structure and function of Endoplasmic reticulum, Golgi complex, Lysosomes (autophagy), Secretory pathway	3
1.3	Structure and function of Mitochondria & Chloroplast	3
1.4	Structure and function of Peroxisomes, Vacuoles, Cell wall &Plasmodesmata	2
1.5	Structure and function of Cytoskeleton-Microtubules, Intermediate filaments and Microfilaments	2
1.6	Extracellular matrix: Cell-cell junctions (tight junctions, gap junctions, adherent junctions& desmosomes). Cell-Matrix junctions (hemidesmosomes& focal adhesions)	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Cell Cycle, Cell Division and Cell Death**	
2.1	Cell cycle: Phases of cell cycle - G_1(Restriction point), S, G_2, M and G_0 (Quiescence phase)	1
2.2	Cyclins&CDK's: Families of cyclins&CDK's (G_1, S, G_2 &M phase), Mechanisms of CDK's regulation (Association with cyclin, activating phosphorylation, inhibitory phosphorylation & CDK's inhibitors, APC/C& SCF)	3
2.3	Check points in cell cycle: G_1-S check point (E2F & p53), G_2-M check point (MPF, ATM &ATR) and mitosis check point (Spindle assembly-APC)	3
2.4	Cell Division: Mitosis-Overview of stages, Mitotic apparatus, distribution of microtubule organizing centers, sister chromatid separation (cohesions&condensins) and cytokinesis; Meiosis: Overview of Meiosis I & II - Stages (synaptonemal complex&chiasmata); Significance of mitosis and meiosis	4
2.5	Apoptosis: Morphological changes, mechanisms- extrinsic & intrinsic pathways and Significance	3
2.6	Necrosis: Characteristics, causes, mechanisms andmorphological patterns	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Chromosome structure and chromatin organization**	
3.1	Structure of chromosome: chromatids, centromere (primary, Secondary constriction/Nucleolar organizer & kinetochore), telomere and satellite; Specialized chromosomes -Polytene and Lamp brush	2
3.2	Components of chromatin: Euchromatin& Heterochromatin, Nucleic acids, histones & non-Histones; Classification and function-Evolutionary importance	3
3.3	Chromatin organization - Structure and organization of nucleosome in chromatin, solenoids, loops and scaffolds, nucleosome phasing	4
3.4	Chromatin remodeling: Histone Modifications-Acetylation, Methylation (lysins& arginine) phosphorylation, ubiquitinylation&SUMOylation, ADP ribosylation and deamination	3
3.5	Dosage compensation, X - chromosome inactivation	2
3.6	Studies on polytene chromosomes for cytogenetic mapping	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Chromosome Detection & aberrations**	
4.1	Karyotyping and its significance	2
4.2	Banding techniques (G, Q, T, R, etc), Insitu hybridization, FISH, SKY	3
4.3	Structural chromosomal abnormalities- Origin of breaks and gaps, ring chromosomes, Isochromosomes, centric fusion, centric fission, breakage fusion bridge cycle. Deletions, duplications, inversions, translocations	3
4.4	Numerical chromosomal abnormalities-Aneuploidy, Polyploidy. Non-Disjunction and Anaphase lag	3
4.5	Chromosome instability and associated syndromes (Ataxia telangiectasia, Fanconi anemia and Bloom syndrome, Xerodermapigmentosa)	3
4.6	Sister chromatid exchanges and its significance	2

PRACTICALS

G152P: CELL BIOLOGY AND CYTOGENETICS

S.No.	Topics to be covered
1	Confocal & Fluorescent microscope
2	Mitosis in somatic tissues of plants (Onion root tips) / animals (Mouse)
3	Meiosis in germinal tissues of plants (Maize/ Lilly) / animals (Grasshopper Testes)
4	Barr Body identification
5	Karyotype analysis
6	G banding
7	Sister chromatid exchanges
8	Polytene Chromosome
9	Induction of polyploidy

REFERENCE BOOKS

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

MSc 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
   d. To comprehend the cell communication 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
   d. Knowledge regarding the cell signaling processes and their importance

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Bioenergetics, proteins and enzymes**	
1.1	Laws of thermodynamics, Gibbs free energy, Enthalpy, Entropy	2
1.2	Importance of water in biological systems, pH, Henderson-Hasselbalch equation	2
1.3	Classification of amino acids based on physico-chemical properties; Peptide bond formation, Biologically active peptides	3
1.4	Proteins-primary, secondary & tertiary, Ramachandran plot; Classification of Proteins based on structure, composition & function	3
1.5	Catalysis, enzymes, coenzymes, cofactors, classification of enzymes, enzyme kinetics	3
1.6	Michaelis-Menten equation, enzyme regulation	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Carbohydrate metabolism**	
2.1	Carbohydrates (Classification, monosaccharides, disaccharides & polysaccharides)	2
2.2	Glycolysis, TCA cycle, Electron transport chain	4
2.3	Gluconeogenesis, Glycogenesis, Glycogenolysis, Glucuronic acid cycle	2
2.4	Pentose phosphate pathway, Entner-Doudoroff pathway, Cori cycle	2
2.5	Photosynthesis, C3 & C4 cycle	4
2.6	Complete overview of carbohydrate metabolism and networks	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Metabolism of lipids, amino acids and nucleotides**	
3.1	Lipids (Classification, fatty acids, steroids)	2
3.2	Catabolism of lipids, Beta-oxidation	3
3.3	Fatty acid biosynthesis, Prostaglandin biosynthesis, Cholesterol metabolism	4
3.4	Amino acid degradation, Urea cycle, biosynthesis of amino acids	3
3.5	Nitrogen metabolism: Nitrate and ammonium assimilation	2
3.6	Nucleotide biosynthesis and degradation	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Cell signaling**	
4.1	Overview of cell signaling	2
4.2	Cell communication (autocrine, endocrine and paracrine), Components of cell signaling (signal molecules, Cell surface receptors, nuclear receptors, second messengers)	2
4.3	G Protein Coupled Receptor Signaling pathway(Structure of GPCRs, G proteins, and GTPases)	3
4.4	RTK signaling pathways (Receptor tyrosine kinase families, Mechanisms of receptor activation)	3
4.5	Signal Transduction Through Ion Channels (Ligand-Gated Channels, Regulation of Ion Channels)	2
4.6	Wnt signaling pathways (Canonical and non-canonical); Notch signaling pathway, Toll-like receptor signaling, Hedgehog pathway	4

PRACTICALS

G153P: FUNDAMENTALS OF BIOCHEMISTRY

S. No.	Topic to be covered
1.	Preparation of buffers
2.	Spectroscopy and Centrifugation
3.	Chromatography
4.	Carbohydrate analysis
5.	Amino acid analysis
6.	Lipid analysis
7.	Enzyme assay
8.	Isolation of Proteins
9.	Estimation of Proteins

REFERENCE BOOKS

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)].

MSc 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. To learn the basic principles of population genetics and impact of evolutionary forces like mutation, selection and migration on genetic variation
   c. Understand the fundamental genetic principles governing variation of quantitative traits in populations, components of variance, heritability and inbreeding depression
   d. To understand the genetic diversity by different methods/ component analysis

2. **Course Outcomes (C.O)**
   a. Understand basic concepts in biostatistics for analyzing biological data
   b. Knowledge of evolutionary factors that influence the genetic structure of populations
   c. Knowledge on quantitative traits and components of variance involved
   d. Help in identifying genetic diversity based on the statistical comparisons

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Biostatistics**	
1.1	Sampling: Random sampling, methods of sampling and Experimental designs, Sampling bias	1
1.2	Descriptive analysis of data: Types of variables, Data alignment and representation, Measures of central tendency, Measures of dispersion, Skewness and Kurtosis	3
1.3	Probability: Concept of probability, Types of events, Laws of probability (Addition and multiplication laws), Bayes theorem and its applications	2
1.4	Probability distributions: Binomial, Poisson, Normal distribution	2
1.5	Hypothesis testing: Null and alternate hypothesis, test of significance, p-value, Type I and Type II errors, confidence intervals and confidence levels	2
1.6	Estimates and test statistics: Chi-square test (test for goodness of fit, homogeneity test, linkage, test of independence), Z test (for proportions and means), t- test (students t test, paired t test), ANOVA - One way and Two-way Anova (F- test)	4
1.7	Correlation and regression analysis	2

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Population Genetics**	
2.1	Population structure: Deme, Gene pool, Random mating population, Estimation of gene and genotype frequencies for biallelic, multiple allelic and X- linked loci	2
2.2	Hardy-Weinberg principle, Establishment of law for a) autosomal biallelic loci b) multiple allelic loci c) X-linked loci	3
2.3	Factors affecting HWE: Mutation (Fate of a mutation, recurrent and reverse mutation pressure), Selection (Fitness and selection coefficient; selection at the phenotype level; selection against recessives, dominants and heterozyotes, selection favoring heterozygotes; Joint effects of selection and mutation,	4
2.4	Migration, Genetic drift (Bottle neck effect and Founder effect), Effective population size, Genetic load (Mutational and segregational load)	3
2.5	Linkage disequilibrium	2
2.6	Effects of Inbreeding and assortative mating	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Quantitative Genetics**	
3.1	Quantitative traits –features (Population mean, average effect, breeding value, dominance deviation, interaction deviation)	3
3.2	Components of Phenotypic Variance: Reaction Norms, Resemblance between relatives	3
3.3	Genetic architecture of quantitative variance, Genotypic Values: Additivity, dominance and Epistasis, genetic covariance (Offspring and one parent, offspring and mid-parent, half sibs, full sibs)	3
3.4	Correlated characters, GxE effects and maternal effects	3
3.5	Heritability (ANOVA and Regression)	2
3.6	Heterosis and Inbreeding depression	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Genetic Distance and Phylogenetic Analysis**	
4.1	Defining genetic variation, factors causing genetic variation, -matting pattern, migration	2
4.2	Genetic diversity-Identifying genetic diversity, application of DNA markers	2
4.3	Neutral Theory- Neutral Theory and prediction for levels of polymorphism and rate of divergence, nearly neutral theory	2
4.4	Molecular clock hypothesis- dating divergence events with a molecular clock	4
4.5	Alignment of genes or proteins- phylogenetic tree construction; Methods for inferring of phylogenetic tree-distance based methods- Cluster analysis, UGPMA, NJ	4
4.6	Phylogenetic Principle component Analysis- Properties, Character based methods- Maximum Parsimony, Maximum Likelihood, Bayesian methods	2

PRACTICALS

G154P: BIOSTATISTICS AND POPULATION GENETICS

S.No.	Topics to be covered
1	Construction of bar diagram, histogram, frequency polygon, pie diagram, box plot
2	Estimation of Mean, Median, Mode, Standard deviation, Variance and standard error for grouped and ungrouped data, Problems on probability
3	Hypothesis testing using Z test and t-test
4	Calculation of correlation and regression
5	Problems on Hardy-Weinberg Equilibrium, Calculation of gene and genotype frequencies
6	Calculation of inbreeding coefficient
7	Estimation of heritability (ANOVA method)
8	NEIs Index

REFERENCE BOOKS

1. Hedrick P.W. Jones & Bartlett, Genetics of Population
2. Hartl D. L. And Clark A. G., Principle of Population Genetics, Sinauer Associates
3. Danial, W. W, Biostatistics, Wiley
4. Khan &Khanum (2004), Fundamentals of Biostatistics, II Revised Edition, Ukaaz Publication
5. Bailey, N.T.J, Statistical methods in Biology, Cambridge Univ. Press
6. Falconer, D (1995) Introduction to Quantitative Genetics, 4th edition, Longman, London.
7. Stickberger, M. W (1990) Evolution, Jones and Bartlett, Boston
8. Fundamentals of Biostatistics, P HanmanthRao and K.Janardhan.
9. Population Genetics- C C Lee.

MSc GENETICS COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for the academic year 2019 onwards)

MSc 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	4	4	20	80	100
2.	G202T	Gene expression and regulation	4	4	20	80	100
3.	G203T	Plant Genetics and Molecular Breeding	4	4	20	80	100
4.	G204T	Human Genetics	4	4	20	80	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	**24**	**32**			**600**

MSc GENETICS I YEAR
SEMESTER- II
THEORY PAPER- I
G201T: GENOME ORGANIZATION & MAINTENANCE

1. **Course Objectives (C. Obj)**
    a. To understand the structure of DNA, genetic features of prokaryotic and eukaryotic genomes
    b. To understand the genome replication in different organisms
    c. To know the causes of DNA damage & their repair mechanisms
    d. To understand the genome rearrangements in prokaryotes and eukaryotes

2. **Course Outcomes (C.O)**
    a. Identify structural, genetic and physical features of prokaryotic and eukaryotic genomes
    b. Describe and identify the replication and recombination process in prokaryotic and eukaryotic genomes
    c. Able to explain the causes of mutation, DNA damage and their repair pathways
    d. Gain knowledge about different mechanisms that occur in the genome rearrangements in prokaryotes and eukaryotes

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Prokaryotic and Eukaryotic Genomes**	
1.1	DNA structure – constituents & chemical linkages, double helical structure, alternative forms, properties and reactions of DNA, DNA bending, DNA supercoiling, triplex-DNA, re-association kinetics	3
1.2	Genomes of Prokaryotes– features and examples of genome organization in prokaryotes (genome size, repeats); plasmids	2
1.3	Genome packaging in prokaryotes- nucleoid, supercoiling, proteins involved in supercoiling (topoisomerases & DNA gyrase)	2
1.4	Bacteriophage and their genomes – diversity of bacteriophage populations, mosaicism, differential gene mobility, driver of phage evolution	3
1.5	Eukaryotic genomes – features of eukaryotic nuclear genomes – gene families, pseudogenes, minisatellites & microsatellites, interspersed repeats	3
1.6	Eukaryotic organellar genomes – physical features, genetic content & origin – mitochondrial & chloroplast genomes	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Genome Replication**	
2.1	Prokaryotic chromosome replication-replicons (Bacterial, Archeal), bacterial replication	2
2.2	Eukaryotic chromosome replication- enzymes, proteins of DNA replication, Telomeric DNA replication	2
2.3	Extra chromosomal replicons- plasmid replication, conjugation transfer, rolling circle model	2
2.4	Organellar genome replication- mitochondria and chloroplast genome replication	4
2.5	Homologous & site specific recombination-synaptonemal complex, bacterial Rec BCD, Holliday junction, lambda recombination	4
2.6	Gene conversion-Neurospora, Drosophila	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Mutation, DNA damage & Repair**	
3.1	Molecular mechanisms of mutations- transitions, transversions, synonymous, missense, nonsense and frameshift mutations	3
3.2	Causes of DNA damage- Spontaneous mutations, induced mutations- chemical agents & physical agents	2
3.3	DNA damage – oxidative damage, depurination, depyrimidination, O6-methylguanines, cytosine deamination, single and double strand breaks	3
3.4	SSB repair system: excision repair system- base excision repair and nucleotide excision repair; mismatch repair	3
3.5	DSB repair system- Non-homologous end joining; SOS repair and Site specific recombination	3
3.6	Importance of DNA repair – Human genetic defects, Xeroderma pigmentosa, Fanconi anemia	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Genome Rearrangements**	
4.1	General features of unprogrammed transposition-types of mobile elements, formation of target site duplication, mobile elements as dispersed repetitive sequences	4
4.2	Transposable elements-prokaryotic transposable elements, P elements of Drosophila, controlling elements of Maize	3
4.3	Retrotransposons class I- Ty elements, Copia elements, class II- F, G & I elements in Drosophila, LINES in mammals	3
4.4	Retrogenes- polypeptide pseudogenes, RNA pseudogenes	2
4.5	Programmed rearrangements –flip-flop inversion, yeast mating type	2
4.6	Programmed amplification-Drosophila chorion genes, Xenopus rDNA, Tetrahymena rDNA	2

PRACTICALS

G251P: GENOME ORGANIZATION & MAINTENANCE

S. No.	Topic to be covered
1	Isolation of genomic DNA from plant tissue
2	Isolation of genomic DNA from Animal tissue
3	Isolation of genomic DNA from human blood
4	Induction of mutants using chemical agents
5	Checking of DNA Purity and concentration –Agarose and Spectrophotometer
6	Problems on DNA Kinetics
7	Tm determination of DNA
8	Comet Assay

BOOKS RECOMMENDED

1. Genes & Genomes – by Maxine Singer & Paul Berg, 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
4. The Cell: A Molecular Approach. 2nd edition. by Cooper GM. Sunderland (MA): Sinauer Associates; 2000.
5. Genetics- A Conceptual Approach by Benjamin A. Pierce.
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.

MSc GENETICS- I YEAR
SEMESTER- II
THEORY PAPER- II
G202T: GENE EXPRESSION AND REGULATION

1. **Course Objectives (C. Obj)**
   a. To know the structure and organization of prokaryotic and eukaryotic genes.
   b. To understand the process of transcription and translation in prokaryotes and eukaryotes
   c. To enable comprehensive understanding of the regulation of gene expression
   d. 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
   b. Analyze gene expression changes in prokaryotes and eukaryotes
   c. Identify differential regulatory mechanisms of gene expression
   d. Classify epigenetic modifications and identify their role in gene expression

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**Prokaryotic and Eukaryotic Genes**	
1.1	Features of genes in prokaryotes and eukaryotes (gene size, gene number, types of genes)	2
1.2	Structure of prokaryotic genes- promoter elements, coding region, terminal region, colinearity & polycistronic mRNA	4
1.3	Organization of prokaryotic genes- Operons: Inducible operon- Lac operon (structural genes, lac repressor, catabolite repression); Repressible operon- Trp operon (structural genes, trp repressor & attenuation)	3
1.4	Structure of eukaryotic genes: components and their function in regulation (core & proximal promoters, enhancers, exons, introns, UTRs), monocistronic mRNA	3
1.5	RNA coding genes (rRNA, tRNA)	2
1.6	Regulatory small RNA coding genes (siRNAs, miRNAs, long non-coding RNAs)	2

Unit Number	Topics to be covered	No. of lectures
Unit 2	**Gene Expression**	
2.1	Transcription in prokaryotes (components; initiation, elongation and termination of transcription)	4
2.2	Transcription in eukaryotes (components; initiation, elongation and termination of transcription)	3
2.3	Post-transcriptional processes: mRNA capping, poly-adenylation and splicing (spliceosome assembly, mechanisms of splicing, self-splicing, Trans-splicing)	3
2.4	Translation in prokaryotes- translation machinery- initiation factors, ribosomes; process of initiation, elongation and termination of translation	2
2.5	Translation in eukaryotes - translation machinery- initiation factors, ribosomes; process of initiation, elongation and termination of translation	2
2.6	Techniques to analyze differential gene expression (Microarrays, RNAseq, qRT-PCR, mass spectrometry-based proteomics, western blotting)	2

Unit Number	Topics to be covered	No. of lectures
Unit 3	**Regulation of Gene Expression**	
3.1	Regulation of transcription- proximal promoter, specific transcription factors, enhancers, multiple promoters, alternate transcription initiation sites, multiple PolyA sites (chicken globin genes, genes controlling yeast mating type, regulation of Xenopus 5S rRNA in oocytes)	2
3.2	Post transcriptional regulation of gene expression: pre-mRNA splicing, miRNA based regulation, Alternate transcript formation - Exon skipping, intron inclusion, alternate splice sites, 5'end variations, 3'end variations (Drosophila sex determination); RNA transport and stability	3
3.3	Regulation of translation: codon usage/bias, 5'UTR based signals, upstream ORFs, start codons, alternate splicing in UTRS, 3'-UTR based regulation (silk fibroin gene)	3
3.4	Post translational regulation of gene expression- protein modifications (Phosphorylation, acetylation, methylation, ubiquitinylation) and Longevity	3
3.5	Tissue-specific regulation of gene expression: Alcohol Dehydrogenase gene, Anthocyanin	2
3.6	Regulation of gene expression during development of an organism-class switching (Alpha and Beta Globin gene expression), Altered gene expression- HOX genes in drosophila	3

Unit Number	Topics to be covered	No. of lectures
Unit 4	**Epigenetic Regulation of Gene Expression**	
4.1	Epigenetics - Epigenetic inheritance, Epigenetic memory and epigenetic states, DNA methylation	2
4.2	Histone modifications in chromatin regulation (Acetylation, methylation, phosphorylation); Histone code	2
4.3	Chromatin remodelling in regulation of transcription: chromatin modifying enzymes and complexes (HATs, HDACs, SWI/SNF)	3
4.4	Small RNAs and LncRNAs in epigenetic regulation, Epigenetic regulation by environmental factors	3
4.5	Dosage compensation and epigenetic process, Genome imprinting and epigenetic reprogramming (Erasure, establishment and maintenance of epigenetic marks); Regulators of homeotic genes—PcG and TrxG proteins	3
4.6	Techniques used in epigenetic studies- bisulfite sequencing, Chip-Seq, Hi-C	3

PRACTICALS

G252P: GENE EXPRESSION AND REGULATION

S.No.	Topics to be covered
1.	Plasmid DNA isolation
2.	PCR
3.	Isolation of mRNA– Trizol method
4.	cDNA synthesis
5.	qRT-PCR
6.	Induction of lac operon
7.	Protein isolation and estimation
8.	Gene expression analysis

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. Principles of Genetics, 7th Edition by Robert. H Tamarin
5. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp, James G. Patton-7th Edition
6. Genes & Genomes – by Maxine Singer & Paul Berg, Universal Science Books, California.
7. Modern Genetic Analysis by Griffiths AJF, Gelbart WM, Miller JH
8. Regulation of Gene Expression by Small RNAs-edited by Rajesh K. Gaur, John J. Rossi, Taylor and Francis group (2009)
9. Gene Regulation by David Latchman, Taylor and Francis group, 2005.

MSc GENETICS I YEAR
SEMESTER- II
THEORY PAPER- III
G203T: PLANT GENETICS & MOLECULAR BREEDING

1. Course Objectives (C. Obj)

a. To understand the basic features of plant breeding, mating and reproductive systems, utilization of plant genetic resources for their conservation and apply the wide hybridization methods for crop improvement
b. To know the methods of breeding for self- and cross-pollinating crops, release of cultivars, seed certification and plant breeder rights
c. To utilize breeding methods for disease resistance/pest resistance and abiotic stress tolerance improvement in crops
d. To explore the biotechnology tools of plant tissue culture, gene transfer and marker assisted selection in crop improvement.

2. Course Outcomes (C. O)

a. Utilize reproductive systems for genetics & breeding of self- and cross-pollinating crops.
b. Apply breeding methods for improvement of self- and cross-pollinating crops.
c. Utilize and develop biotic and abiotic stress tolerant crop varieties and improve nutritional quality of the crops.
d. Practice and use biotechnology tools for breeding, transgenic plant production and crop improvement.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Principles of Plant Breeding**	
1.1	Introduction to plant breeding: Domestication of crop plants – Centers of origin and diversity	3
1.2	Basic features of plant breeding, Objectives of plant breeding	1
1.3	Plant genetic resources and conservation strategies: Sources of plant genetics resources; Methods of germplasm conservation; Evaluation and utilization of plant genetic resources	3
1.4	Reproductive systems in plants: Sexual reproduction – self and cross fertilization – Autogamy, Allogamy and often cross pollinated plants; Asexual reproduction and Apomixis	3
1.5	Genetic basis of breeding: Mating systems of plants	3
1.6	Wide hybridization: Inter-specific crosses and inter-generic hybridization; Role of wide hybridization in crop improvement	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Plant Breeding Methodologies**	
2.1	Breeding Methods in self-pollinating crops: Pure line selection; Pedigree method; Bulk population methods; Single seed descent method; Back cross method and Multilines	3
2.2	Breeding methods in cross pollinating crops: Mass selection; Ear-to-row selection; Progeny selection and Recurrent selection methods,	3
2.3	Hybrid Breeding – Development and evaluation of inbred lines, A, B and R lines, Development of hybrids, male sterility systems	3
2.4	Mutation breeding: types of mutations – mutagenic agents: physical and chemical mutagens; Mutation breeding in seed crops and vegetative propagated crops – TILLING and EcoTILLING	3
2.5	Cultivar release - Seed certification and multiplication	2
2.6	Plant breeder's rights – role of UPOV, working of PBRS	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Specific Breeding Methods**	
3.1	Breeding for disease resistance: Genetics of pathogenicity, Genetics of disease resistance; Methods of breeding for disease resistance	3
3.2	Breeding for insect resistance: Mechanisms of insect resistance; Breeding methods for pest resistance	3
3.3	Breeding for abiotic stress tolerance - drought, salinity	3
3.4	Breeding for abiotic stress tolerance - cold stress tolerance, heat stress tolerance and flooding tolerance	3
3.5	Breeding for yield and morphological traits – ideotype concept, lodging and shattering resistance, photoperiod response, early maturity	2
3.6	Breeding for quality traits - Nutritional quality, Improved protein content and Improved oil quality, low phytate	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Biotechnological Approaches for Crop Improvement**	
4.1	Introduction to plant cell-tissue culture: Cellular totipotency, factors affecting shoot bud differentiation; Plant tissue culture techniques in crop improvement - Micropropagation	3
4.2	Tissue culture applications; Haploids and di-haploids in breeding, Somaclonal variations and their role in crop improvement, Protoplast fusion in crop improvement and breeding, germplasm preservation	3
4.3	Transgenics in crop improvement: Gene transfer methods in plants, Production of transgenics for biotic and abiotic stress tolerance; Cis-genic approaches	3
4.4	Transgenic male-sterility systems and development of hybrids	2
4.5	Gene silencing: RNAi mechanism & its applications for crop improvement	2
4.6	Molecular plant breeding tools: Molecular markers, mapping of genes– mapping populations, QTL mapping, Marker assisted selection – MAS schemes	3

PRACTICALS

G253P: PLANT GENETICS & MOLECULAR BREEDING

S. No.	Topic to be covered
1	Floral morphology and pollination methods in self-pollinating and cross-pollinating crops
2	Cell & explant culture/ Induction of organogenesis
3	Somatic embryogenesis/Isolation of protoplasts & culture
4	Embryo culture/Somaclonal variation to select disease resistance
5	Agrobacterium/Biolistic mediated gene transfer
6	Anther and Pollen culture
7	Heterosis
8	Linkage analysis
9	RAPD/SSR analysis

BOOKS RECOMMENDED

1. Principles of Plant Genetics and Breeding (2012) by George Acquaah, Second 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 Altman Professor, Paul Micheal Hasegawa.s

MSc GENETICS I YEAR
SEMESTER- II
THEORY PAPER- IV
G204T: HUMAN GENETICS

1. **Course Objectives (C. Obj)**
   a. To know about the human genetic traits and patterns of inheritance
   b. To understand the molecular basis of genetic diseases
   c. To analyze types of gene linkage for association and mapping
   d. To discuss different approaches for disease gene identification and methods of physical mapping.

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

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
Unit 1	**Gene Transmission in Families**	
1.1	Pedigree analysis in monogenic traits- Autosomal dominant inheritance, recessive inheritance (consanguinity and inbreeding), X-linked dominant, X-linked recessive, Y-linked, sex influenced & sex-limited disorders	3
1.2	Pedigree analysis- Maternal inheritance of disorders caused by mutations in the mitochondrial genome (homoplasmy and heteroplasmy)	1
1.3	Factors affecting pedigree pattern- penetrance (complete & incomplete), variable expressivity, anticipation, genomic imprinting (Prader-Willi Syndrome, Angelman Syndrome), Mosaicism (mosaics, chimeras)	4
1.4	Genotype & phenotype correlation- genetic heterogeneity (allelic & locus), phenotypic heterogeneity	2
1.5	Segregation analysis of monogenic conditions- Complete and Incomplete ascertainment	3
1.6	Multifactorial inheritance- Threshold model, Heritability ,Twin studies in genetic analysis	3

Unit Number	Topics to be covered	No. of lectures
Unit 2	**Genetics and Molecular Basis of Human Disorders**	
2.1	Molecular basis of human chromosome anomalies: Numerical and Structural chromosomal Disorders	3
2.2	Inherited disorders due to defects of amino acid metabolism, Lipid metabolism, Carbohydrate metabolism & Purine metabolism	4
2.3	Inherited disorders due to defects in membrane transport (Cystic fibrosis) & Defects in receptor proteins (Familial Hypercholesterolemia)	2
2.4	Inherited disorders due to defects in structural proteins (DMD & BMD) & Collagen disorders (Osteogenesis imperfecta)	2
2.5	Single gene disorders- Hemoglobinopathies (Sickle cell disease, Thalassemias)	2
2.6	Complex genetic diseases – Hypertension, Diabetes mellitus, Coronary Artery Disease	3

Unit Number	Topics to be covered	No. of lectures
Unit 3	**Linkage Analysis for Mapping Human traits**	
3.1	Linkage: Phases of linkage, recombination frequency	2
3.2	Parametric methods of linkage: Lod score, Y- statistics, sib-pair method	3
3.3	Non-parametric methods of linkage: Allele sharing methods (Identical by Descent, affected sib method)	3
3.4	Extensions of linkage studies for genetic heterogeneity, reduced penetrance and epistasis	2
3.5	Types of genetic markers for linkage, multipoint linkage analysis (Homozygosity mapping)	3
3.6	Genetic association studies: SNP analysis (Genetic models and Allelic effects), Haplotype analysis, Linkage disequilibrium analysis, transmission disequilibrium test (TDT)	3

Unit Number	Topics to be covered	No. of lectures
Unit 4	**Strategies for Disease Gene Identification and Gene Mapping**	
4.1	Approaches for disease gene identification: Forward & Reverse genetics	2
4.2	Functional cloning (Eg: Hemophilia)	2
4.3	Positional dependent cloning (Eg: DMD, Cystic Fibrosis)	3
4.4	Position independent cloning- Candidate gene approach (Eg: Marfan's Syndrome, Retinitis Pigmentosa)	3
4.5	Low resolution mapping: Sub- chromosomal mapping, Chromosomal break points, FISH, Somatic cell hybrid mapping, Radiation hybrid mapping	3
4.6	High resolution mapping: Restriction mapping; VNTR, microsatellite markers for mapping; EST mapping, SNP mapping, Conserved region mapping (CpG site mapping), Sequencing	3

PRACTICALS

G254P: HUMAN GENETICS

S.No.	Topics to be covered
1.	Construction of Pedigrees
2.	Identification of modes of inheritance from pedigrees
3.	Segregation analysis
4.	Detection of metabolic disorders by biochemical/chromatographic method
5.	Estimation of Lod score from pedigrees
6.	Sib pair method
7.	Haplotype analysis
8.	Identification of chromosome anomalies using Idiograms (Klinefelter's syndrome/Turner's syndrome/ Down's Syndrome/ Cri-du-Chat Syndrome)

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. The principles of human biochemical genetics. By Harry Harris. North-Holland, Amsterdam; American Elsevier, New York. 328 pp. 1970.
4. Curt Stern (1960) Principles of Human Genetics, Publisher: W. H. Freeman & Company; 2nd Edition.
5. Thompson and Thompson Genetics in Medicine (7th Edition), Nussbaum, Mclnnes, Willard
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.