M.Sc COURSE STRUCTURE
CHOICE – BASED CREDIT SYSTEM
DEPARTMENT OF GENETICS, OSMANIA UNIVERSITY
(Proposed for academic year 2016 onwards)

Semester – I

Sl. No.	Syllabus Ref. No	Subject	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	G101 T	Principles of Inheritance	4	4	20	80	100
2.	G 102 T	Cell Biology & Cytogenetics	4	4	20	80	100
3.	G 103 T	Fundamentals of Biochemistry	4	4	20	80	100
4.	G 104 T	Biostatistics and Population Genetics	4	4	20	80	100
	PRACTICALS #						
1.	G 151 P	Principles of Inheritance	2	4		50	50
2.	G 152 P	Cytogenetics	2	4		50	50
3.	G 153 P	Fundamentals of Biochemistry	2	4		50	50
4.	G 154 P	Biostatistics and Population Genetics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER – II

Sl. No.	Syllabus Ref. No	Subject	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	G 201 T	Genome organization and maintenance	4	4	20	80	100
2.	G 202 T	Gene expression and regulation	4	4	20	80	100
3.	G 203 T	Plant Genetics & Molecular Breeding	4	4	20	80	100
4.	G 204 T	Human Genetics	4	4	20	80	100
	PRACTICALS#						
1.	G 251 P	Genome organization and maintenance	2	4		50	50
2.	G 252 P	Gene expression and regulation	2	4		50	50
3.	G 253 P	Plant Genetics & Molecular Breeding	2	4		50	50
4.	G 254 P	Human Genetics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER - III

Sl. No.	Syllabus Ref. No	Subject	Credits	Teaching Hours/ Week	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	G 301 T	Recombinant DNA Technology	4	4	20	80	100
2.	G 302 T	Immunogenetics	4	4	20	80	100
3.	G 303 T	**ELECTIVE 1**: Diagnosis and Therapeutics for Genetic Diseases (A) / Cell & Tissue Engineering (B)	4	4	20	80	100
4.	G 304 T	**ELECTIVE 2:** Plant Biotechnology (A)/ Mouse developmental biology and disease models (B)	4	4	20	80	100
5.	SEC - 3	Personality Development					
	PRACTICALS #						
1.	G 351 P	Recombinant DNA Technology	2	4		50	50
	G 352 P	Immunogenetics	2	4		50	50
3.	G 353 P	Diagnosis and Therapeutics for Genetic Diseases (A) / Cell & Tissue Engineering (B)	2	4		50	50
4.	G 354 P	Plant Biotechnology (A)/ Mouse developmental biology and disease models (B)	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER - IV

Sl. No.	Syllabus Ref. No	Subject	Credits	Teaching Hours/ Week	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	G 401 T	Bioinformatics	4	4	20	80	100
2.	G 402 T	Applied Microbial Genetics	4	4	20	80	100
3.	G 403 T	**Elective 3:** IPR & Biosafety (A) / Genetic Toxicology (B)	4	4	20	80	100
3.	G 404 T	Genomics & Society **ID**	4	4	20	80	100
	PRACTICALS #						
1.	G 451 P	Bioinformatics	2	4		50	50
2.	G 452 P	Applied Microbial Genetics	2	4		50	50
3.	G 453 P	Project Work	4	8		100	100
		Total	**24**	**32**			**600**
		GRAND TOTAL	**96**	**128**			**2400**

M.Sc (Genetics) Semester – I
Paper : I (G101T) PRINCIPLES OF INHERITANCE

UNIT I: Eukaryote Model Systems for Genetic Analysis

1.1 Life cycle and importance of *Drosophila*
1.2 Life cycle and importance of *Neurospora*
1.3 Life cycle and importance of Yeast
1.4 Life cycle and importance of *C. elegans*,
1.5 Life cycle and importance of Zebra fish,
1.6 Life cycle and importance of *Arabidopsis*
1.7 Life cycle and importance of Maize.

UNIT II: Mendelian Analysis of Inheritance and Extension to Mendel's Laws

2.1 Mendel's Laws of Inheritance.
2.2 Allelic interactions; co-dominance and incomplete dominance; overdominance; pleiotropism; lethals and sub-lethals; penetrance and expressivity.
2.3 Position effect Variegation.
2.4 Epistasis: Non-allelic interactions and modification of Mendelian ratios.
2.5 Multiple alleles-ABO blood groups in humans, Rh blood group incompatibility; self sterility alleles in plants; complex loci in *Drosophila*.
2.6 Inborn errors of metabolism, one gene – one enzyme concept
2.7 Inheritance of polygenic traits with specific examples

UNIT – III: Linkage and Gene Mapping in Eukaryotes

3.1 Chromosomal basis of inheritance and Cytological basis of crossing over- Sterns experiments in *Drosophila,* Creighton and Mc Clintock experiment in maize
3.2 Inheritance of linked genes - Coupling and Repulsion phase, meiotic recombination, gene mapping in *Drosophila* and maize using two point and three point test crosses with an emphasis on interference and coefficient of coincidence
3.3 Evidence for crossing over occurring at four strand stage – Tetrad analysis and gene mapping in *Neurospora;* gene mapping using unordered tetrads in yeast.
3.4 Mitotic crossing over – *A. niger*

UNIT – IV: Sex determination and Extra-nuclear inheritance

4.1 Genetic basis of sex determination in *Drosophila* and *S.alba*
4.2 Dosage compensation; Sex -linked, sex-limited and sex-influenced characters
4.3 Extra-nuclear inheritance: Maternal effects; mitochondria and chloroplasts inheritance
4.4 Male Sterility in plants and their applications.

Practicals (G 151 P) : Principles of Inheritance

1. Life cycle of Drosophila, maintenance of stocks.
2. Problems based on Mendelian Laws – maize cobs and Drosophila genetics stocks
3. Segregation analysis in Drosophila and maize
4. Mitotis in Onion root tips/ Mouse
5. Meiosis in Maize/ Grasshopper Testes
6. Problems on linkage & sex linkage

M.Sc (Genetics) Semester – I
Paper : II (G 102 T) CELL BIOLOGY AND CYTOGENETICS

Unit I: Cell cycle and Cell division

1.1 Structure and function of cellular organelles (Endoplasmic reticulum, Golgi complex, lysosomes, vacuoles, peroxisomes, mitochondria, chloroplast, secretory pathway)
1.2.Cytoskeleton and extracellular matrix (Microtubules, intermediate filaments, microfilaments, integrins, focal adhesions, hemidesmosomes, selectins, cadherins, adherin junctions, desmosomes, tight junctions, gap junctions, plasmodesmata and cell wall)
1.3. Cell cycle- Phases of cell cycle, restriction points, cell cycle determining genes, G_0 Phase (Quiescence phase, Points of no return), totipotency of stem cells.
1.4.Chromosome segregation in mitosis and meiosis - mitotic apparatus, distribution of microtubule organizing centres, formation of synaptonemal complex, cytokinesis
1.5.Cell death: Apoptosis (Intrinsic and Extrinsic pathways), necrosis and autophagy

Unit II: Chromatin organization

2.1. Components of chromatin - Chromosome structure, Euchromatin and Heterochromatin
2.2. Chromatin organization - Structure and organization of nucleosome in chromatin, solenoids, loops and scaffolds, nucleosome phasing, active and inactive states of chromatin.
2.3. Chromatin Modifications – Histone modifications and their effect
2.4. Dosage compensation, X - chromosome inactivation
2.5. Evolutionary significance

Unit III: Chromosome Abnormalities

3.1. Structural chromosomal abnormalities- Origin of breaks and gaps, ring chromosomes, Isochromosomes, centric fusion, centric fission- Mechanisms involved. Deletions, duplications, inversions, translocations.
3.2. Numerical chromosomal abnormalities- Aneuploidy, Polyploidy. Non-Disjunction and Anaphase lag.
3.3. Chromosome instability and associated syndromes
3.4. Sister chromatid exchanges and its significance

Unit IV: Detection and analysis of chromosomal alterations

4.1. Karyotyping and its significance
4.2. Banding techniques (G, Q. T, R, etc)
4.3. Studies on polytene chromosomes for cytogenetic mapping.
4.4.Chromosome break points Mapping(Deletion mapping, translocation mapping, Inversion mapping).
4.5. Insitu hybridization, FISH, SKY

Practicals (G 152 P) : Cell Biology and Cytogenetics

1. Barr Body identification
2. Karyotype analysis
3. G banding
4. Polytene Chromosome
5. Induction of polyploidy

M.Sc (Genetics) Semester – I
Paper : III (G 103 T) Fundamentals of Biochemistry

Unit I: Bioenergetics, Enzymology and Biomolecules

1.1 Laws of thermodynamics, Gibbs free energy, Enthalpy, Entropy
1.2 Proteins (Primary, secondary & tertiary structures), Ramachandran plot
1.3 Catalysis, enzymes and enzyme kinetics, Briggs-Haldane reaction, Michaelis-Menten equation, Coenzymes, Cofactors, enzyme regulation.

Unit II: Carbohydrate metabolism

2.1 Carbohydrates (Classification, monosaccharides, disaccharides, oligosaccharides & polysaccharides).
2.2 Glycolysis, TCA cycle, Electron transport chain, Gluconeogenesis, Glycogenesis, Glycogenolysis, Glucuronic acid cycle, Pentose phosphate pathway, Entner-Doudoroff pathway, Cori cycle, Photosynthesis, C3 & C4 cycle

Unit III: Metabolism of lipids and amino acids

3.1 Lipids (Classification, fatty acids, steroids), Hydrolysis of triacyl glycerols, Beta-oxidation, Fatty acid biosynthesis, Prostaglandin biosynthesis, Cholesterol metabolism.
3.2 Amino acids, Amino acid degradation, Urea cycle, Overview of amino acids Biosynthesis
3.3 Nitrogen metabolism: Nitrate and ammonium assimilation
3.4 Nucleotide biosynthesis and degradation.

Unit IV: Cell signalling

4.1 Cell communication (autocrine and paracrine), Components of cell signalling (Growth factors, receptors, adaptors and signal transducers)
4.2 Calmodulin pathway, GPCR signalling pathways, RTK signaling pathways, Wnt signalling pathways, Toll-like receptor signalling pathways, second messengers.
4.3 Overview of signalling.

Practicals (G 153 P) : Fundamentals of Biochemistry

1. Preparation of buffers.
2. Spectroscopy, Centrifugation, X-ray diffraction, NMR
3. Carbohydrate Analysis
4. Amino acid Analysis
5. Isolation and measurement of proteins
6. SDS-PAGE
7. Column chromatography Gel filtration (size exclusion)

M.Sc (Genetics) Semester – I
Paper – IV (G 104 T) BIOSTATISTICS AND POPULATION GENETICS

UNIT I: Biostatistics

1.1.Sampling and Experimental design
1.2.Descriptive analysis of data: Types of variables, Data alignment and representation, Measures of central tendency, Measures of dispersion
1.3.Concepts of probability: Axioms of probability
1.4.Probability distributions : Binomial, Poisson, Normal distribution.
1.5.Hypothesis testing: Null and alternate hypothesis, test of significance, Type I and Type II errors, confidence intervals and confidence levels
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).
1.7.Correlation and regression (Simple regression, multiple regression, logistic regression)

UNIT II: Population Genetics

2.1. Population structure, Gene pool, Estimation of gene and genotype frequencies for biallelic, multiple allelic and X- linked loci.
2.2. Hardy-Weinberg principle, Establishment of law for a) autosomal biallelic loci b) multiple allelic loci c) X-linked loci.
2.3. Factors affecting HWE: Mutation, Selection, Migration, Genetic drift, Effective population size
2.4. Genetic load: Mutational and segregational load
2.5. Linkage disequilibrium
2.6. Effects of Inbreeding and assortative mating.

UNIT III: Quantitative Genetics

3.1. Quantitative traits –features (Population mean, average effect, breeding value, dominance deviation, interaction deviation)
3.2. Components of Phenotypic Variance: Reaction Norms, Resemblance between relatives
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)
3.4. Correlated characters, GXE effects and maternal effects
3.5. Heritability (ANOVA and Regression)
3.6. Heterosis and Inbreeding depression

UNIT IV: Genetic Distance And Phylogentic Analysis

4.1. Genetic diversity
4.2. Genetic distance and measures of relatedness, Molecular dating
4.3. Cluster Analysis: Construction of cluster diagrams and dendrograms
4.4. Principal Component Analysis

4.3. Phylogenetic analysis (UPGMA)
4.4. Bayesian methods for phylogenetic estimation

Practicals (G 154 P): Biostatistics And Population Genetics

1. Data alignment and Descriptive analysis of data- Manual and Excel
2. Problems on probability
3. Problems on Chi-Square test
4. Problems on Z test
5. Problems on t-test
6. One way and two-way ANOVA
7. Calculation of correlation and regression
8. Calculation of gene and genotype frequencies
9. Problems on Hardy-Weinberg Equilibrium
10. Calculation of inbreeding coefficient
11. Estimation of heritability
12. NEIs Index

M.Sc (Genetics) Semester – II
Paper – I (G 201 T) GENOME ORGANIZATION AND MAINTENANCE

Unit I: Genome Organization

1.1.DNA structure
1.2.Prokaryotic genome organization
1.3.Eukaryotic genome organization
1.4.Extrachromosmal genetic elements (plasmids, mitochondrial genome, chloroplast genome)
1.5.Horizontal gene transfer (transformation, transduction, conjugation. Genome islands)
1.6.Transposable elements and their implication in genome evolution
1.7.Bacteriophages (lambda phage)

Unit II: Genome Replication and Replication Associated Errors

2.1. DNA replication
2.2. Bacterial chromosomal replication
2.3. Eukaryotic chromosomal replication
2.4. Plasmid Replication
2.5. Replication of mitochondrial and chloroplast genomes
2.6.Regulation of genome replication
2.7. Replication associated errors

Unit III: DNA Damage and Repair

3.1. Internal and external agents causing DNA damages
3.2. DNA damages (Oxidative damages, Depurinations, Depyrimidinations, O6-methylguanines, Cytosine deamination, single and double strand breaks)
3.3. Mechanisms of DNA damage (transition, transversion, frameshift, nonsense mutations)
3.4. Repair mechanisms (Photo reactivation, excision repair, mismatch repair, post replication repair, SOS repair)

Unit IV: Genome Rearrangements

4.1. Whole genome duplication
4.2. Segmental duplication
4.3. Single nucleotide variations
5.4. Homologous recombination
5.5. Non-homologous end joining
5.6. Site-specific recombination
5.7 Transposon and repeats mediated rearrangements
5.8. Gene conversion

Practicals (G 251 P): Genome Organization and Maintenance

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

M.Sc (Genetics) Semester – II
Paper – II (G 202 T) GENE EXPRESSION AND REGULATION

Unit I: Structure of Prokaryotic and Eukaryotic Genes

1.1.Structure of prokaryotic genes
1.2.Organization of prokaryotic genes into operons
1.3.Structure of eukaryotic genes (introns, exons, UTRs, core and proximal promoters, enhancers)
1.4.Number of genes in prokaryotes and eukaryotes
1.5.RNA coding genes (rRNA, tRNA)
1.6.Regulatory small RNA coding genes (miRNAs)

Unit II: Gene Expression

2.1. Transcription machinery in prokaryotes and eukaryotes
2.2. Transcription process (initiation, elongation, termination, processing of transcripts)
2.3. Translational machinery in prokaryotes and eukaryotes
2.4.Translation process (initiation, elongation, termination, folding, processing)
2.5.Co-ordinated regulation of gene expression in prokaryotes and eukaryotes

Unit III: Regulation of Gene Expression

3.1. Regulation of transcription (proximal promoter, specific transcription factors, enhancers, multiple promoters, alternate transcription initiation sites, multiple PolyA sites)
3.2. Post transcriptional regulation of gene expression (pre-mRNA splicing, miRNA based regulation)
3.3. Alternate transcript formation (Exon skipping, intron inclusion, alternate splice sites, 5’ end variations, 3’ end variations)
3.4. Regulation of translation (codon usage/bias, 5’UTR based signals, upstream ORFs, upstream, start codons, alternate splicing in UTRS, 3’-UTR based regulation)
3.5. Post translational regulation of gene expression

Unit IV: Epigenetic Regulation of Gene Expression

4.1. Overview of epigenetic regulation
4.2. Chromatin remodelling and gene expression
4.3. Histone modifications and gene expression
4.4. Small RNA based epigenetic regulation
4.5. Propagation of epigenetic regulation (genome imprinting)

Practicals (G 252 P): Gene Expression and Regulation

1. Plasmid DNA isolation
2. Isolation of mRNA – trizol method
3. Understanding Human genome project
4. Epigenetic Analysis – Insilico
5. Serum miRNA analysis.

M.Sc (Genetics) Semester – II
Paper – III (G 203 T) PLANT GENETICS AND MOLECULAR BREEDING

UNIT I: Principles of Plant Breeding

1.1 Introduction to plant breeding. Domestication of crop plants – Centres of origin and diversity; Basic features of plant breeding and Objectives of plant breeding
1.2 Plant genetics resources and conservation strategies. Sources of plant genetics resources; Methods of germplasm conservation; Evaluation and utilization of plant genetic resources
1.3 Reproductive systems in plants: Sexual reproduction – self and cross fertilization – Autogamy, Allogamy and often cross pollinated plants; Asexual reproduction and Apomixis
1.4 Genetic basis of breeding: Mating systems of plants; Wide hybridization – Inter-specific crosses and inter-generic hybridization; Role of wide hybridization in crop improvement.

UNIT II: 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 Multi lines
2.2 Breeding methods in cross pollinating crops: Mass selection; Ear-to-row selection; Progeny selection and Recurrent selection methods, Hybrid Breeding – Development and evaluation of inbred lines, A, B and R lines, Development of hybrids., male sterility systems
2.3 Mutation breeding: Physical and Chemical mutagens; Mutation breeding in seed crops and vegetative propagation; and TILLING.
2.4 Cultivar release and certification, Cultivar release; Seed certification and multiplication; Plant breeders rights

UNIT III: Specific Breeding Methods

3.1 Breeding for disease resistance. Genetics of pathogenecity; Genetics of disease resistance; Methods of breeding for disease resistance
3.2 Breeding for insect resistance: Mechanisms of insect resistance; Breeding methods for pest resistance
3.3 Breeding for abiotic stress tolerance, Breeding for drought, salinity, temperature and flood tolerance
3.4 Breeding for nutritional improvement, Nutritional quality, Improved protein content and Improved oil quality

UNIT IV: Biotechnological Approaches for Crop Improvement

4.1 Plant tissue culture techniques in crop improvement. Introduction to plant cell-tissue culture techniques, Haploids and di-haploids, Somaclonal variation, Protoplast fusion, Micro propagation
4.2 Transgenics in crop improvement: Gene transfer methods in plants; Production of

transgenics for biotic and abiotic stress tolerance; Transgenic male-sterility systems and development of hybrids; Cis-genic approaches

4.3 Gene silencing: RNAi and its applications for crop improvement

4.4 Molecular plant breeding tools, Molecular markers, Marker assisted breeding, Genome mapping – QTL mapping

Practicals (G 253 P): Plant Genetics and Molecular Breeding

1. Floral morphology and pollination methods in self-pollinating and cross pollinating crops.
2. Callus Initiation and Plantlet Regeneration.
3. *Agrobacterium*/Biolistic mediated gene transfer
4. RAPD/SSR analysis
5. Linkage analysis
6. Heterosis

M.Sc (Genetics) Semester – II
Paper IV (G204 T) HUMAN GENETICS

UNIT I: Genes in Families

1.1 Patterns of Inheritance (AD, AR, XD, XR, YL, Maternal inheritance)
1.2 Pedigree analysis
1.3 Extensions to Mendelian inheritance
- 1.3.1 Incomplete penetrance and variable expressivity
- 1.3.2 Epistasis, pleiotropism
- 1.3.3 Gametic imprinting
- 1.3.4 Mosaicism
- 1.3.5 Anticipation

1.3 Genetic and phenotypic heterogeneity (Inter and Intra allelic heterogeneity)
1.4 Segregation analysis
1.5 Analysis of multifactorial condition-polygenic inheritance
- 1.5.1 Threshold model
- 1.5.2 Twin studies in genetic analysis

UNIT II: Linkage Analysis

2.1 Linkage detection and estimation
- 2.1.1 Parametric and non-parametric methods: Lod score, y- statistics, sib-pair method, IBD, affected relatives methods

2.2 Linkage analysis through family studies-Homozygosity mapping
2.3 Extensions of linkage studies for genetic heterogeneity, reduced penetrance and epistasis
2.4 Population based Linkage analysis
2.5 Whole genome linkage analysis
2.6 Genetic models and Allelic effects
2.7 Different types of genetic markers
2.8 Linkage disequilibrium analysis
2.9 Haplotype analysis
2.10 Analysis of gene-phenotype interactions

Unit III: Genetic Basis of Human Diseases

3.1 Molecular pathology of Chromosome anomalies
- 3.1.1 Numerical chromosomal disorders
- 3.1.2 Structural chromosomal disorders
- 3.1.3 Chromosome instability syndromes

3.2 Molecular basis of single gene disorders
- 3.2.1 Autosomal Dominant and recessive disorders
- 3.2.2 X-linked dominant and recessive disorders, Y-linked, X-influenced and X-limited disorders

3.3 Inherited biochemical diseases
- 3.3.1 Enzyme defects- amino acid metabolism
- 3.3.2 Lipid metabolic disorders
- 3.3.3 Carbohydrate associated disorders
- 3.3.4 Defects in purine metabolism
- 3.3.5 Defects in membrane transport
- 3.3.6 Defects in structural proteins
- 3.3.7 Collagen disorders
- 3.3.8 Defects in receptor proteins

3.4 Complex genetic diseases – Hypertension, Diabetes mellitus
3.5 Mitochondrial diseases
3.6 Cancer as a genetic disease
3.7 Familial and sporadic cancers – Oncogenes, tumor suppressor genes, mutator genes.

UNIT IV: Strategies for Disease Gene Identification and Gene Mapping

4.1 Approaches for gene identification
- 4.1.1 Functional cloning
- 4.1.2 Positional cloning
- 4.1.3 Position independent candidate gene approach
- 4.1.5 Position dependent candidate gene approach
- 4.1.5 Epigenetic signatures
- 4.1.6 Transcriptome analysis

4.2 Association studies
4.3 Case-control studies
- 4.3.1 Population based studies
- 4.3.2 GWAS

4.4 Mapping:
- 4.4.1 Low resolution mapping: Sub- chromosomal mapping, Chromosomal break points, FISH, cytogenetic methods, Somatic cell hybrid mapping, Radiation hybrid mapping
- 4.4.2 High resolution mapping: DNA FIBRE FISH , Restriction mapping, VNTR microsatellite markers for mapping, EST mapping, STS mapping, SNP mapping, Conserved region mapping: IRE, CpG site mapping, Promoter site recognition
- 4.4.3 Sequencing

4.5 Mapping for single gene disorders
4.6 Mapping for complex genetic disorders

Practicals (G 254 P): Human Genetics

1. Pedigree analysis
2. Sister chromatid exchanges
3. Amino acidopathies and carbohydrate metabolic error identification
4. Segregation analysis
5. Problems on Parametric and non-parametric variables
6. Lod score
7. Sib pairs
8. Haplotype analysis
9. LD Maps