University of Delhi

M.Sc. Examination in Genetics

Part-I M.Sc. (Previous) Examination in Genetics

(2005-2006)

Theory (60 x 5 =300)		**Scheme of Examination**	**Marks**
Course I	:	Concepts of Genetics	(60)
Course II	:	(a) Biotsatistics and Computer Application (b) Population genetics	(60)
Course III	:	Cytogenetics and Genome Organisation	(60)
Course IV	:	Gene function	(60)
Course V	:	Concepts of Biochemistry	(60)

Practicals (100 x 2 = 200)

Paper I	:	Based on Theory Papers	(100)
Paper II	:	Based on Theory Papers	(100)

I CONCEPTS OF GENETICS

History of Genetics: Role of Breeding systems, life cycles of some genetically useful organisms such as viruses, bacteria, *Neurospora*, *Drosophila*, maize and *Homo sapiens;* Mendelian genetics- Mendel's laws of inheritance; Expression and interaction of genes, allelic and nonallelic interaction; Multiple alleles, pseudoalleles, Complex loci, complementation; Linkage, crossing –over and chromosome mapping. Microbes as model systems in genetic analysis, Principles, basic procedures and terminology of microbial genetics; Gene mapping in bacteria and viruses, fine-structure mapping. Genetic analysis in fungi, tetrad analysis, gene conversion. Mechanism of recombination, mitotic mapping. Penetration and expressivity, heritability; Qualitative and quantitative traits, polygenic inheritance; Sex-linked inheritance; Interaction of genes and environment, Extranuclear genetics-Role of organellar genome, maternal inheritance and maternal effect. Genetic variation – History, Categories of mutations, Genome, chromosome and gene mutations, Somatic mutations, Extrachromosomal mutations, origin and frequency of spontaneous mutations, Mutator genes, Mobile genetic elements, Chromosomal alterations and evolution, Induced mutations, Physical and chemical mutagenes, Methods of mutation induction, Screening and selection of mutations, Molecular basis of spontaneous and induced mutations, DNA repair mechanisms, Reversion, Transposon mutagenesis, *In vitro* mutagenesis, Site-specific mutagenesis, Environmental mutagenesis, Genetic hazards of radiation, Radiation damage to proteins, Radiation safely, Genotoxicity test systems.

II (a) BIOSTATISTICS AND COMPUTER APPLICATIONS

Principles and applications of statistical methods in biological research; Basic statistics- Samples and populations, experimental design, Data analysis, Graphs, Average, Coefficient distributions (Chi-square, binomial, Poisson and normal), Tests of statistical significance, Regression and correlation, Analysis of variance; Basics of computer application-Introduction to structural organization and types of digital computers, operating systems, Word processing, Computer programs in the analysis of statistical methods and preparation of graphs, Data base on bibliography and gene bank, information retrieval, Computer analysis of structure and sequence of nucleic acids and proteins, practical training in operating a computer system.

II (b) POPULATION GENETICS

History, Genetics polymorphism, Panmictic & Mendelian population, Hardy-Weinberg genetic equilibrium, Causes of changes in gene frequency (migration, selection, genetic drift, inbreeding and mutations), Natural and artificial selection, Heritability, Genetic load, Fisher's fundamental theorem, Coadapted gene complex, Super genes, Linkage disequilibrium, Genetic distance, Molecular genetic analysis of populations, Mechanisms of speciation and evolution and speciation.

III CYTOGENETICS AND GENOME ORGANIZATION

Chromosome structure, organization: Chromatin structure, nucleosomal and higher order structures, morphology and basic functions; Techniques in the study of chromosomes and applications. Mitotic and meiotic chromosomes, banding, karyotyping, chromosome labeling and cell cycle analysis, in situ hybridization, chromosome painting, gene mapping, somatic cell hybrids, premature chromosome condensation; Special types of chromosome-sex chromosomes, sex chromatin, B-chromosome, polytene and lambrush chromosomes; Numerical and structural changes in the chromosome. Mechanisms of sex determination in plants and animals. Dosage compensation; Genome organization in viruses, prokaryotes and eukaryotes (animals and plants); Organization of nuclear and organellar genomes; c-value paradox; Techniques in genome analysis, genome mapping and functional genomics; Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable Elements, LINES, SINES, Alu family, mechanisms of DNA amplification, genome evolution; Fine structure of gene, split genes, pseudogenes, overlapping genes and multigene families. DNA and RNA as genetic material; Chemistry and structure of DNA.

IV GENE FUNCTION

DNA replication in prokaryotes and eukaryotes; Importance of RNA in information transfer, Types of RNA and their structure; Transcription: General principles, assembly of the basic transcription apparatus, types of RNA polymerases, controls at initialization, elongation and termination; RNA processing: processing of mRNA, tRNA and rRNA, capping and polyadenylation, RNA editing, mRNA stability; Genetic code, Deciphering the code, codon usage; Protein synthesis: structure of ribosome, role of tRNA and rRNA, translation and its control, translational introns and protein splicing; Concepts of protein folding and transport: Chaperons, signal peptide hypothesis, transport of proteins to organelles; DNA binding proteins: structure and function, methods of isolating DNA binding proteins and analyzing DNA- Protein interactions. Ribozymes, Antisense RNA.

V CONCEPTS OF BIOCHEMISTRY

The living vs the non-living state: Lehninger's thesis of "molecular logic" of life; biomolecules: building blocks, macromolecules; informational macromolecules. Proteins as informational macromolecules; chemistry of aminoacids; the primary, secondary and tertiary structure of polypeptides; peptides; peptide subunits and quaternary structure; metabolism of proteins and aminoacids. Enzymes as biocatalysts; specificity of enzyme kinetics; inhibition of enzyme action; assay of enzymes; mechanism of enzyme action: regulation of enzyme activity *in vitro*; enzyme classification.

Cellular metabolism: energy-yielding and energy-requiring processes; metabolic pathways; thermodynamics of cellular reactions; energy-rich compounds; biological oxidation and its coupling to ATP synthesis.

Laws of Thermodynamics: Energy production and transduction in autotrophs; photosynthesis; mitrochondrial oxidative phosphorylation- the chemiosmotic theory; organizational and chemistry of energy transducing machinery of the eukaryotic cell; redox potential. Metabolic cycles and energy production: the Embeden - Meyerhof pathway; the hexose - monophosphate shunt; oxidation of fatty acids; significance of the TCA cycle. Gluco- and glycogenolysis; regulation of carbohydrate metabolism. Integration and regulation of metabolic pathways; hormones as regulators of metabolism and development; chemistry and mechanisms of action of hormones.

Fatty acid breakdown and synthesis; chemistry of lipids- their biosynthesis and breakdown; regulation of lipid metabolism; interrelationship between carbohydrates and lipid metabolism. Organization of biological membranes: the fluid-mosaic model and its implication for membrane-mediated cellular events.

Techniques in biochemistry; Adsorption and Fluorescence; pH, pK and Buffers used in biology; Hydrodynamic methods; Chromatography-TLC, GLC, HPLC, FPLC, Gel filtration, ion exchange and affinity chromatography; X-ray diffraction and crystallography and its application in protein structure determination; Microscopy- Bright field, Fluorescence, phase contrast, video and electron microscopy; Radioisotopes and their use in biology- Autoradiography, radioactive labeling of biological macromolecules; Ligand binding, membrane filtration and equilibrium dialysis.

University of Delhi

M.Sc. Examination in Genetics

Part-II M.Sc. (Final) Examination in Genetics

(2005-2006)

Theory (60 x 5 = 300)		**Scheme of Examination**	**Marks**
Course VI	:	Regulation of Gene Expression And Development.	(60)
Course VII	:	Advanced Microbial Genetics	(60)
Course VIII	:	Plant Breeding and biotechnology	(60)
Course IX	:	Human Genetics and Medical Biotechnology	(60)
Course X	:	Recombinant DNA Technology	(60)
Practicals (100 x 2 = 200)			
Paper I	:	Based on Theory Papers	(100)
Paper II	:	Based on Theory Papers	(100)

VI REGULATION OF GENE EXPRESSION AND DEVELOPMENT

Gene regulation in prokaryotes: Operon model of regulation (with examples of *lac*, *trp* and *ara*); Lytic and lysogenic switch in lambda. Gene regulation in eukaryotes: overview of gene regulation in animals and plants using examples of galactose-utilization in yeast; heat shock gene expression; regulation of SV40 and CaMV 35S viral promoters; hormonal control of gene regulation in animals and plants. Regulation of Cell cycle, signal transduction. Global influences on gene expression: chromatin conformation and methylation; Molecular genetics of development: Introduction to developmental biology- Zygote development and differentiation in animals and plants; Model systems to study pattern formation- *Dictyostelium*: Life cycle, aggregation and slug formation, mechanism of cell differentiation in the slug and final body formation; *Caenorhabditis elegans*: cell lineage and mosaic development; vulval cell formation. *Drosophila:* Polarity determination of embryo by maternal genes, segmentation genes and formation of body segments; Homeotic genes specifying segment identity; Vertebrate limb: specification of axis and limb field, zone of polarizing activity and digit formation, hox genes and limb pattern, regeneration; *Arabidopsis:* Life cycle, Embryogenesis and seed development, genes involved in flower development.

VII ADVANCED MICROBIAL GENETICS AND TECHNOLOGY

Methods of genetic analysis: Genetic analysis of mutants: recombination and genetic mapping. Test of allelism, Methods of gene transfer in bacteria- Conjugation: Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', heteroduplex analysis, mechanism of chromosome transfer, molecular pathway of recombination. Chromosome transfer in other bacteria; Transformation: natural transformation systems, Biology of transformation, transformation and gene mapping, Chemical-mediated and electrotransformation; Transduction: discovery, generalized and specialized or restricted transduction, Phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction, Temperature phage lambda and mechanism of specialized transduction, gene mapping, fine-structure mapping; Techniques for studying bacteriophages- Virulent phage (T_4) and Temperate phage (phage lambda), Important aspects relationship, impunity and repression. Site specific recombination (lambda and P1), transposable phage (phage Mu), genetic organisation, and transposition, Mu as a genetic tool; Plasmids: Types, detection, replication, partitioning, copy-number control and transfer. Properties of some known plasmids; Genetic rearrangements and their evolutionary significance: Phase variation in *Salmonella* and others; Aspects of fungal Genetics: Meiotic and mitotic mapping, gene conversion, mitotic segregation and recombination, heterothallism and mating type switches. Parasexual analysis-protoplast fusion, transformation, gene disruption, plasmids, retroposon and retrotransposon. Microbial strain improvement: genetic resources and genetics of economically useful and adaptive traits, methods of strain improvement, Prospects of microbial technology and genetic engineering, synthesis of microbial and recombinant products: Fermentation Technology- basic principles and techniques used, applications of fermentation, optimization and scaling-up; Immobilization techniques.

VIII PLANT BREEDING AND BIOTECHNOLOGY

Plant breeding- History; Genetic resources- centres of diversity and origin of crop plants, Law of homologous variation, genetics resources, Plant breeding- Mode of reproduction and breeding strategies, Plant diseases and pests and defensive mechanisms, Breeding of self and cross pollinated and vegetatively propagated crop plants, Heterosis breeding, Polyploidy and haploids in breeding, Wide hybridization, Mutation breeding, Breeding crops to contain useful and adaptive traits; seed production and variety development and its conservation; Marker assisted breeding using molecular probes (RAPDs, RFLPs and AFLPs); Plant tissue culture and somatic cell genetics – role of growth regulators, Micropropagation, Artificial seeds, Germplasm storage *in vitro*; Embryo rescue, Haploids and triploids, Secondary products, Protoplast culture and fusion, Cybrids, Somaclonal variation, Mutant selection *in vitro* and by transposon tagging, Plant genetic engineering using recombinant DNA techniques, T-DNA and viral genome-derived plant vectors, Transformation using plant protoplasts, Particle gun-mediated transformation, Organelle transformation, Engineering of crops for useful agronomic traits and metabolic pathways, Transgene

silencing, Strategies to avoid gene silencing and improve gene expression in transgenic plants, Description and uses of antisence RNA, ribozymes in plants; Ethics and plant genetic engineering.

IX HUMAN GENETICS AND MEDICAL BIOTECHNOLOGY

History and development of human genetics; Organisation of the human genome; Genes and chromosome- structure, function and inheritance; Repetitive DNA in human genome –Alu and SINE repeats; Methods for Genetic study in man- Pedigree analysis, Chromosomal analysis, Biochemical analysis, Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping, hybridoma technology, polyclonal and monoclonal antibodies), Molecular genetic analysis; Mammalian tissue culture techniques; congenital abnormalities; Clinical aspects of autosomal and sex chromosomal disorders, Inborn errors of metabolism; Haemoglobinopathies; Human genome mapping- Physical, Genetic and Microsatellite mapping, Human genome project; inherited human diseases- single gene diseases, Polygenic/multifactorial disease, identification and isolation of disease genes- positional cloning and functional cloning; Cancer genetics; Immunogenetics Diagnostic genetics (Cytogenetics, Biochemical, Molecular); DNA fingerprinting; Gene manipulation; Gene therapy; Genetic counselling; *In vitro* fertilization and embryo transfer; Transgenic technology- Methods of DNA transfer- Use of viral vectors, Microinjection, ES cell transformation and knock out mouse models; Applications in basic and applied research; Animal models in human genetics research; Animal biotechnology- bioproducts from cell culture, cryopreservation of embryos and cells; Ethics and human genetics.

X RECOMBINANT DNA TECHNOLOGY

Historical emergence of recombinant DNA technology; basic principles and methods; Properties, mode of action and uses of restriction endonucleases and other enzymes; electrophoretic techniques; Cloning- Phage and plasmid vectors, cosmids, shuttle vectors, yeast vectors, artificial chromosomes, chromosome walking, chimeric gene construction; Genomic and cDNA libraries; colony hybridization; Southern blot, northern blot and western blot; Dot and slot blots; Methods of preparing probes; Transformation, selection and expression of cloned DNA; Sequencing of DNA and proteins; Synthesis of oligonucleotides; Site-directed mutagenesis; Protein engineering; Gene isolation and synthesis; Polymerase chain reaction; DNA footprinting; RAPD, RFLP and AFLP; Restriction mapping; Containment (Physical and biological); Application of r-DNA technology in agriculture, health, medicine and industry; Bioethics and genetic engineering.