MAHARSHI DAYANAND UNIVERSITY, ROHTAK-124001, INDIA

(NAAC Accredited 'A' Grade State University established under Haryana Act No. XXV of 1975)

SCHEME & SYLLABUS

M.Sc. Genetics
(2 Year Programme)

Choice Based Credit System (CBCS)
(w.e.f. Academic Session 2016-17)

DEPARTMENT OF GENETICS

Web site: http://www.mdurohtak.ac.in

DEPARTMENT OF GENETICS

Credit Matrix for M.Sc. Genetics Program w.e.f. 2016-17

SEMESTER	CORE PAPER (INCLUDING PRACTICAL)	DISCIPLINE SPECIFIC ELECTIVE (INCLUDING PRACTICAL)	FOUNDATION COURSE	OPEN ELECTIVE (INTERDISCIPLINARY)	PROJECT WORK/DISSERTATION	TOTAL
I	**28**	**-**	**-**	**-**	**-**	**28**
II	**16**	**8**	**2**	**3**	**-**	**29**
III	**12**	**12**	**-**	**3**	**-**	**27**
IV	**8**	**-**	**-**	**-**	**20**	**28**
TOTAL	**64**	**20**	**2**	**6**	**20**	**112**

REQUIRED CREDITS FOR M.SC GENETICS TWO YEAR COURSE : TOTAL=112

CORE PAPER = 64
DISCIPLINE SPECIFIC ELECTIVE = 20
OPEN ELECTIVE COURSE = 6
FOUDATION COURSE = 2
DISSERTATION = 20

INSTRUCTION FOR THE STUDENTS

Course Types:

- **Core Paper (C):-** There are Core Papers in every semester. These are to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in the said discipline/ Course of study.
- **Discipline Specific Elective (D):-** These are Elective papers which can be chosen from a pool of papers given by the department. It will be supportive to the discipline of study & mandatory as per course curriculum.
- **Foundation Course (F)**:- The Foundation Course is based upon the content that leads to Knowledge enhancement/proficiency/skill development. It is mandatory as per course curriculum & to be taken from pool provided by M.D. University Rohtak.
- **Open Elective (O)**:-Open elective course may be from an unrelated discipline. It is Interdisciplinary/Open Elective & mandatory as per course curriculum. Choice may be from any other Subject/Department of M.D. University campus Rohtak/pool provided by M.D. University Rohtak. .
- **Dissertation/ Field work/Project -Dissertation/**Project /Field work/ is discipline centric & mandatory as per course curriculum. Student has to study with an advisory support by concerned teacher

SCHEME OF EXAMINATION

M.SC. GENETICS - CHOICE BASED CREDIT SYSTEM (W.E.F. ACADEMIC SESSION 2016-17)

SEMESTER –I							
Paper No.	**Nomenclature**	**Course structure**			**Internal assessment M.M**	**External M.M**	**Total Marks**
		L+T+P	**Total Credits**	**Hrs./week**			
Core Paper							
16GEN21C1	Concepts of Genetics	4+0+0	4	4	20	80	100
16GEN21C2	Microbial Genetics	4+0+0	4	4	20	80	100
16GEN21C3	Human Genetics	4+0+0	4	4	20	80	100
16GEN21C4	Molecular Cell Biology	4+0+0	4	4	20	80	100
16GEN21C5	Developmental Genetics	4+0+0	4	4	20	80	100
16GEN21C6	Lab course-I **(**Based on 1C1&1C2 papers**)**	0+0+4	4	8	-	-	100
16GEN21C7	Lab course-II**(**Based on 1C3,1C4&1C5 papers**)**	0+0+4	4	8	-	-	100

Total Credits=28

SEMESTER –II

Student will opt any **one** of the given four **Discipline specific** elective course (D1 to D4) along with respective Lab Course(-D5)

The students are required to take **one** paper of **Foundation course (F)** of their choice from pool provided by M.D. University Rohtak. The students are also required to take **one** paper **Open Elective**(O) of their choice from any other Subject/Department of M.D. University campus Rohtak/pool provided by M.D. University Rohtak. .

Paper No.	**Nomenclature**	**Course structure**			**Internal Assesment (M.M)**	**External (M.M)**	**Total Marks**
		L+T+P	**Total Credits**	**Hrs. /week**			
Core Paper							
16GEN22C1	Molecular Genetics	4+0+0	4	4	20	80	100
16GEN22C2	Immunogenetics	4+0+0	4	4	20	80	100
16GEN22C3	Plant Genetics	4+0+0	4	4	20	80	100
16GEN22C4	Lab course-I**II (**Based on 2C1,2C2&2C3 papers)	0+0+4	4	8	-	-	100
Discipline specific(Elective)							
16GEN22D1	Conservation Biology	4+0+0	4	4	20	80	100
16GEN22D2	Bioinformatics and Biostatistics	4+0+0	4	4	20	80	100
16GEN22D3	Medical Genomics	4+0+0	4	4	20	80	100
16GEN22D4	Genetics of Medicinal Plants	4+0+0	4	4	20	80	100
16GEN22D5	Lab course-IV(for respective discipline specific elective courses)	0+0+4	4	8	-	-	100
Foundation course							
	To be chosen by the student from common pool of the university		2				
Open Elective course							
	To be chosen by the student from common pool of the university		3				

Total Credits=29

SEMESTER –III

Student will opt **any one** of the Discipline specific elective course Group 1 (D1 to D3) and any one of the Discipline specific elective course Group II (D4 to D6) along with respective Lab Course(-D7)**.** The students are also required to take **one** paper **Open Elective(O**) of their choice from any other Subject/Department of M.D. University campus Rohtak/pool provided by M.D. University Rohtak. .

Paper No.	**Nomenclature**	**Course structure**			**Internal Assessment M.M**	**External**	**Total Marks**
		L+T+P	**Total Credits**	**Hrs./ week .**			
Core Paper							
16GEN23C1	Recombinant DNA Technology	4+0+0	4	4	20	80	100
16GEN23C2	Population and Evolutionary Genetics	4+0+0	4	4	20	80	100
16GEN23C3	Lab course-V**(**Based on 3C1&3C2 papers)	0+0+4	4	8	-	-	100
Discipline specific(Elective)							
16GEN23D1	Human Molecular Genetics	4+0+0	4	4	20	80	100
16GEN23D2	Drosophila Genetics	4+0+0	4	4	20	80	100
16GEN23D3	Somatic Cell Genetics	4+0+0	4	4	20	80	100
16GEN23D4	Plant molecular Genetics	4+0+0	4	4	20	80	100
16GEN23D5	Microbial Technology	4+0+0	4	4	20	80	100
16GEN23D6	RNAi technology	4+0+0	4	4	20	80	100
16GEN23D7	Lab course-VI(for two respective discipline specific elective course)	0+0+4	4	8	-	-	100
	Open Elective course (To be chosen by the student from common pool of the university)		3				

Total Credits=27

	SEMESTER –IV						
Paper No.	**Nomenclature**	**Course structure**			**Internal Assessment (M.M)**	**External (M.M)**	**Total Marks**
		L+T+P	**Total Credits**	**Hrs./week.**			
Core Paper							
16GEN24C1	Social, Ethical Issues in Genetics	4+0+0	4	4	20	80	100
16GEN24C2	Lab Design and Bio safety	4+0+0	4	4	20	80	100
16GEN24C3	Dissertation/Project Work/Seminar		20				300

Total Credits=28

Grand Total Credits=112

INTERNAL ASSESMENT

The distribution of the weightage of marks will be as under:-

Internal Assessment	**20% or 20 marks**
Sessional Test	10% or 10 marks
Assignment/Presentation	5% or 5 marks
Attendance*	5 marks

*Distribution of marks for attendance is as under:-

Attendance Classification:

(a)	65% to 70%	=	2 marks
(b)	71% to 75%	=	3 marks
(c)	76% to 80%	=	4 marks
(d)	81% onwards	=	5 marks

SEMESTER-I
(Core Paper)

PaperCode:16GEN21C1 **CONCEPTS OF GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit 1:
Brief introduction: **Life cycles** of Genetically important experimental organisms: *Neurospora crassa*, *Saccharomyces cerevisiae*: Baker's Yeast, *Arabidopsis thaliana*: A Fast-Growing Plant, *Drosophila melanogaster*: The fruit fly.
Mendelism: Mendel's experimental organism: the garden pea. Basic Principles of Inheritance: Monohybrid crosses (the principle of Segregation); Dihybrid crosses (the principle of independent Assortment); Applications of Mendel's Principles: The Punnett square method, Forked-line method, Probability method, Chi square test.
Extensions of Mendelism: Incomplete Dominance and Co-dominance, Multiple Alleles. Testing gene mutations for allelism, gene interactions : Complementation, Epistasis, Pleiotropy, Penetrance and Expressivity.
Unit 2:
Chromosome Theory of Inheritance: Experimental evidence linking the inheritance of genes to chromosomes, Molecular organization of prokaryotic and eukaryotic chromosomes, chromomere, kinetochores, centromeres, telomeres, heterochromatin/ euchromatin; Linkage, Recombination and crossing over: Early evidence for linkage and genetic recombination, crossing over as the physical basis of recombination, cytological demonstration of crossing over, genetic recombination and construction of genetic maps, interference and coincidence.
Unit 3:; Polyploidy and Aneuploidy in nature, tissue-specific polyploidy and polyteny (polytene and lampbrush chromosomes), Qualitative traits and Quantitative Traits and their inheritance, Polygenic inheritance, continuous discontinuous variation, Genetic variance, heritability & QTL mapping; Extra-nuclear Inheritance in nature: Mitochondrial and Chloroplast genes, maternal inheritance, Transposable elements/jumping genes. Mutation: definition, types, induction, detection, molecular basis and significance of mutations in nature, mutagenic agents (exogenous & endogenous).
Unit 4:
Genetic Material: Prediction of DNA structure & chemistry, Alternative forms of DNA, negative and positive supercoiling; One DNA molecule per chromosome, DNA packaging, Nucleosome structure, DNA scaffolds & loops; Fine structure of gene, split genes, pseudogenes, overlapping genes & multigene families; c value paradox and central dogma; Introduction to Bioinformatics- Biological Databases: Primary, secondary & specialized databases. Types of databases- Nucleotide sequence database, EMBL, Genebank, Unigene, Genome biology, Protein dBase, 3D structure databases, Alignments using BLAST and FASTA.

Suggested Readings:

1. **Principles of Genetics** by D. Peter Snustad and Michael J Simmons
2. **Genetics: A Conceptual Approach** by Benjamin A. Pierce
3. **The Science of Genetics** by Alan G. Atherly, Jack R. Girton, John F. McDonald
4. http://highered.mcgraw-hill.com/sites/007352526x/student_view0/genetic_portrait_chapters_

SEMESTER-I

(Core Paper)

Paper Code:16GEN21C2 **MICROBIAL GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Bacteria as model systems in genetic analysis: Mutation, recombination, test of allelism, gene mapping; Methods of gene transfer in bacteria; Conjugation: Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination; Chromosome transfer in other bacteria.

Unit-II

Transformation: Natural transformation systems, Biology and mechanism of transformation, transformation and gene mapping, Chemical-mediated and electro transformation; Transduction: Discovery, generalized and specialized or restricted transduction, Phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction. Temperate phage lambda and mechanism of specialized transduction, gene mapping, fine structure mapping.

Unit-III

Structure and classification of bacteriophage: Virulent phage (T_4) and Temperate phage (lambda); Lytic and lysogenic cycles, phage-host relationship; immunity and repression, Site specific recombination (lambda and P1); Techniques for the study of bacteriophages. Transposable phage (phage Mu): Genetic organization, and transposition, Mu as a genetic tool; Plasmids: Types, detection, replication, incompatibility, partitioning, copy-number control and transfer; Properties of some known plasmids. Genetic rearrangements and their evolutionary significance: Phase variation in *Salmonella*

Unit-IV

Microscopy: Light Microscopy-Introduction, Magnification and Resolution, Lens aberrations, Distortion of image and curvature of field;.Types of microscopes- Compound, Comparison, Fluorescence, Polarized, Stereo, Their basic principles, working and applications; Electron Microscopy- Introduction, Historical review, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Theory and basic principles, Instrumentation, applications

Suggested readings:

1. Microbial Genetics (1994) - Maloy S., Cronan J., Freifelder D, Jones and Bertlett
2. Fundamental Bacterial Genetics (2004) - Trun N and Trempy J, Blackwell Publ.
3. Modern Microbial Genetics (2002)-Streips U. N. and Yasbin R.E., Wiley-Liss
4 Molecular Genetics of Bacteria (2003) -Sneider L. and Champness W. ASM Publishers
5. Genetics of Bacteria -Scaife J., Academic Press
6. Genetics of Bacteria and Viruses (2006)- Birge E. A., Springer
7. Molecular Genetics of Bacteria -Dale J.W. and Park S, Wiley

SEMESTER-I

(Core paper)

Paper Code:16GEN21C3 **HUMAN GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Overview of historical milestones in Human genetics, Study tools in Human Genetics: pedigree- gathering family history symbols, construction of pedigree, pedigree analysis in monogenetic traits; Autosomal dominant and recessive inheritance; Sex linked dominant and recessive inheritance; Consanguinity and its effects; Sex Chromosomes and autosomes, Different sex determination systems in nature; Sex linked anomalies: Haemophilia, Colour blindness; Sex limited and sex influenced traits; Sex determination in Man, TDF & SRY, Testicular feminization syndrome; Lyon hypothesis, Single active X hypothesis, Sex chromatin and drum sticks, Genetic mosaics.

Unit-II

Human Karyotypes: Harvesting of cells for chromosome analysis, conventional and specialized staining protocols, Banding patterns, Nomenclature of aberrant karyotypes; Human genome mapping methods: Physical mapping, Introduction to physical map markers; Radiation hybrids; Fluorescence in situ hybridization; SKY, Comparative genome hybridization, long range restriction mapping; High resolution mapping-STS/RFLP/EST/MS/SNP/sequencing.

Unit-III

Human Health and Disease: Chromosomal numerical and structural alteration: Mechanisms of Deletion, Duplication, Translocation, Aneuploidy and Nullisomy; Common syndrome according to numerical and structural alteration; Genetics and clinical features of Syndromes (Klinefilter, Down's, Turner, Achondroplasia, Edwards, Polydactyly); Single gene and diseases: Beadle and tatum experiment; Inherited enzyme defects in man (PKU, Alkaptonuria, Albinism, Galactosemia); Haemoglobinopathies: ABO blood group system, Rh blood group, Thalassemia syndromes; Multifactorial disorders: Genetics factors in Diabetes, Schizophrenia, Huntington's disease, Alzheimer's disease.

Unit-IV

Cancer genetics: Cancer cells, Oncogenes, Tumor suppressor genes ; Leukaemias, Lymphomes, myelomas; ; Human genome project: History and concepts, gateways, goals, role of sequencing, distribution of GC content, CPG islands, main conclusions, current activities; DNA finger printing ; Prenatal diagnosis;
Human cloning and Eugenics; Ethical, legal and social issues in Human Genetics.

Suggested readings:

1. Human Genetics: Problems and Approaches (1997) - T Vogel F. and. Motulsky A. GT, Springer Verlag
2. Human Molecular Genetics (2003) 3rd ed. - Strachan T & Read A, Garland Science
3. An Introduction to Human Molecular Genetics (1999) - Mechanism of Inherited Diseases Pasternak J Fitzgerald, Science Press
4. Human Genetics (2009) - Cummings, M.R, Cehage Learning, USA.
5. Principles and branches of Medical Genetics, Emery and Rimoih, Churchill Livingstone, Newyork, Vol-1-3.
6. Human Cytogenetics-Constitutional analysis (1995) (Ed) D.E. Rooney, Oxford University Press.
7. Recombinant DNA (1992) - J.D. Watson Gillman, Scientific American books, W.H, freeman company N.Y.
8. Human Genetics (1993) - The molecular revolution McConkey, Edwin H, Jones & Bartlett publishers.

SEMESTER-I

(Core paper)

Paper Code:16GEN21C4 **MOLECULAR CELL BIOLOGY** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Diversity of cell size and shape; Cell Theory; Structural organization and function of intracellular organelles: Cell wall, Nucleus, Mitochondria, Golgi bodies, lysosomes, Ribosome, Endoplasmic reticulum, Peroxisomes, plastids, Vacuoles, Chloroplast, Structure & function of cytoskeleton and its role in motility; Cell adhesion, gap junction, Extra cellular matrix. Endosymbiotic origin of mitochondria and chloroplast.

Unit-II

Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, chromosomal movements and control of cell cycle; Membrane transport processes, transport molecules, inhibitors, ion gradient, proton pumps (in oxidative phosphorylation, in photosynthesis & in bacteria); Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers and regulation of signaling pathways.

Unit-III

Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids(DNA ,RNA :detail structure & types) and vitamins); Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds).

Unit-IV

Bioenergetics, glycolysis, coupled reaction, group transfer, biological energy transducers; Enzyme kinetics: Factors affecting enzyme activity- pH, temperature, time of incubation, enzyme concentration and substrate concentration. Derivation of Michaelis-Menten equation, Kcat/Km and its significance, regulation of enzyme activity, allosteric enzymes ;Biophysical methods**:** Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy; Structure determination using X-ray diffraction and NMR analysis using light scattering; Different types of mass spectrometry and surface plasma resonance methods.

Suggested Readings

1. Lodish et al., Molecular Cell Biology Freeman and Company 2000.
2. Smith and Wood. Cell Biology, Chapman and Halls 1996
3. Watson et al. Molecular Biology of the gene. Pearson Prentice Hall, USA 2003
4. Benjamin Lewin. Gene X, Jones and Barlett Publishers, 2010.
5. Lehninger Principles of Biochemistry 4th Ed By David L. Nelson and Michael M. Cox, WH Freeman and Company.
6. Principles of Biochemistry (Hardcover) By Geoffrey Zubay. Publisher: McGraw Hill College.
7. Biochemistry By Lubert Stryer. WH Freeman and Co.

SEMESTER-I
(Core paper)

Paper Code:16GEN21C5 **DEVELOPMENTAL GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I
Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; Morphogenetic gradients, pattern formation, cell fate and cell lineages; Mosaic versus regulative development; Genomic imprinting .

Unit-II
Fertilization, Types of cleavage, Gastrulation; Cell movement and formation of germ layers in frog, Chick and mouse; Implantation and formation of the placenta in mammals; Gastrulation in mammals-formation of primitive streak, morphogenetic movements and induction; Organogenesis and foetal development; Formation of vulva in *C. elegans.*

Unit – III
Drosophila: Embryonic development, Maternal genes and formation of body axes, Segmentation genes, and Homeotic genes function, Imaginal disc development, P-element and insertional mutagenesis; Pattern forming genes and expression in mammalian embryos, Axes formation and Hox genes; Development of mammalian brain-cerebral cortex-cell lineages; Limb development and regeneration in vertebrates; Lens development-fibre differentiation; Programmed morphogenetic histogenetic cell death (apoptosis); Erythropoesis, mylopoesis; Ageing.

Unit - IV
Embryonic stem cells and their applications; Clinical embryology: (Gametogenesis, Follicular development, egg release, fertilization implantation, Types of placenta), Brief account of hormonal control of reproduction; Gonadal malformation and their genetic basis; Reproductive failure and infertility; Assisted reproduction.

Suggested readings:
1. Developmental Biology (2003) - Gilbert S. F, Sinauer Asso.
2. Principles of Development (2002) - Wolpert L et al., Oxford University Press
3. The Art of the Genes (1999) - How Organisms Make Themselves Coen E. Oxford University Press
4 Genetic Analysis of Animal Development (1993) 2nd ed. - Wilkins A. S., Wiley-Liss
5. Biological Physics of the Developing Embryo (2005) - Forgacs G. & Newman S. A., Cambridge University Press..

SEMESTER-I

(Core paper)

Paper Code: 16GEN21C6	**LAB COURSE-I**	**Credits: 4**
Time: 6 Hours	**(Based on 1C1& 1C2 papers)**	**Max. Marks: 100**

SEMESTER-I

(Core paper)

Paper Code: 16GEN21C7	**LAB COURSE-II**	**Credits: 4**
Time: 6 Hours	**(Based on1C3,1C4&1C5 papers)**	**Max. Marks: 100**

SEMESTER-II

(Core paper)

Paper Code: 16GEN22C1 **MOLECULAR GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit -I
DNA, RNA as genetic material; DNA replication, Repair and Recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication; DNA damage and repair mechanisms: nucleotide excision repair, base excision repair, SOS repair, recombinational repair, Photoreactivation; Structure and function of different types of RNA, RNA transport; RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation.

Unit- II
Protein synthesis and processing: Ribosomes, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post- translational modification of proteins. Computation methods; Nucleic method and protein sequence databases, data mining method for sequence searches, motif analysis and prediction.

Unit-III
Structure of genes in eukaryotes: Split genes-exons and introns; different kinds of introns and junction sequences; origin of introns (exon early intron early hypothesis); coding potential and overlapping genes; pseudogenes-their origin and function; cryptic genes- their origin and function; gene transfer between nucleus and other organelles.
Gene regulation and levels of regulation, evidences and experimental designs/methodologies, role of genetic analysis in understanding gene function and regulation; Yeast- Gene regulation in a single celled eukaryote using a model case of GAL gene.

Unit-IV
Genetic regulation in eukaryotes; DNA alteration (Gene amplification, programmed DNA rearrangement, DNA methylation); Spatial and temporal control, Tubulin gene in plant, globin genes in animals); Molecular control of transcription in eukaryotes (Enhancer, Silencer, enhancer trap mutagenesis, transcription factors, alternate promoters, alternate splicing, molecular organization of transcriptionaally active DNA); Induction of transcriptional activity by environmental and horizontal factors; Translational control.

Suggested readings:
1. Benjamin Lewin. Gene X, 10th Edition, Jones and Barlett Publishers 2010.
2. J D Watson et al., Biology of Gene, 6th Edition, Benjamin Cummings publishers Inc. 2007
3. Alberts et al., Molecular Biology of the Cell, Garland, 2002
4. Primose SB, Molecular Biotechnology, Panima, 2001.
5. Watson et al. Molecular Biology of the gene. Pearson Prentice Hall, USA 2003
6. Benjamin Lewin. Gene X, Jones and Barlett Publishers, 2010.

SEMESTER-II

(Core paper)

Paper Code: 16GEN22C2 **IMMUNOGENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I
Overview of immunity; General properties of immune system, Immunological memory, Specificity; Innate and Adaptive immunity;Cells and organs of immune system; Hematopoiesis; Antigens (Haptens, epitopes, adjuvants) ; Antibodies; Immunoglobulin classes; Cytokines, Interferon, Colony stimulating factor, Transforming growth factor; Complement pathways.

Unit-II
Immune response: MHC complex, Class I, II, III molecules; Genetic map of H-2 complex & HLA Complex; T cell receptor complex; Subtractive hybridization; Ig gene super family;Humoral & cell mediated immune response (antigen recognition, processing and presentation),Hypersensitivity reactions (I, II, III & IV types).

Unit-III
Immunogenetics: Organization of immuno globulin genes, Genetic control of light chains ((Lambda & Kappa), Genetic control of heavy chains; Genomic rearrangement during B lymphocyte differentiation, Somatic recombination events, Antibody class switching, Allelic exclusion, Somatic mutation; Genetic control of antibody diversity.

Unit-IV
Immunity in health and disease: Disorders of immune system: Self tolerance & auto immunity, causative factors; Defects: Thyroiditis, IDDM, SLE, Rheumatoid arthritis; Immuno suppression: Severe combined immuno deficiency (SCID), AIDS; Tissue transplantation: Laws, types of grafts rejection, GVHR, alloantigens; Vaccines; Primary antigen, antibody reaction: Radio immunoassay, Enzyme linked immunosorbant assay; Secondary antigen antibody reaction: Precipitation, Agglutination & Immuno electrophoresis.

Suggested readings:
1. Immunology - Kuby J. W. H., Freeman
2. Essentials of Immunology (2014) - Ivan M. Roitt, Wiley-Blackwell
3. Fundamentals of Immunology (2008) -William E. Paul Lippincott, Williams & Wilkins.
4. Immunology Understanding Immune system –Elgert K D, John Wiley and sons.

SEMESTER-II

(Core paper)

Paper Code: 16GEN22C3

PLANT GENETICS **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all

Unit I

Plant Genetics: Introduction; Problems related to higher plants, including polyploidy inheritance, self-incompatibility, cytoplasmic inheritance, mutable alleles; complex loci, genome analysis, recombination and mutagenesis; cytological aspects of hybridity and apomixes; chromosomes as they affect breeding behaviour.

Unit 1I

Plant Breeding: History of plant breeding; Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Polyploidy and haploids in plant breeding; Cytogenetic tools in Plant breeding; Limitations of conventional breeding.

Unit III

Plant Tissue Culture: History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; In vitro differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on in vitro culture and regeneration; Molecular basis of plant organ differentiation.

Unit IV

Molecular markers for genome mapping: Principles of genetic linkage, concept of genetic distance, development and choice of mapping populations, linkage map construction – relational, integrated and comparative maps; Principles and methods of QTL mapping; Principle and applications of gel filtration, ion exchange & affinity chromatography; Thin layer chromatography; Gas chromatography; GLC; High pressure liquid chromatography (HPLC), Fast protein liquid chromatography (FPLC); Ultracentrifugation (Velocity and buoyant density).

Suggested Readings

1. Principles of Plant Breeding, Allard R. W. Wiley & Sons
2. Plant Breeding Theory and Practice, Stoskopf N. C., Tomes D. T. & Christie, B. R. Westview Press
3. Plant Cytogenetics, Singh R. J. CRC Press
4. Genome mapping in Plants, Paterson A. H. Academic Press
5. Molecular markers in Plant Genetics and Biotechnology, Vienne D. INRA
6. Quantitative Genetics, Genomics and Plant Breeding, Kang M. S. CABI Publishing
7. Plant Molecular Breeding , Newbury H. J. CRC press
8. Bhojwani SS. 1983. Plant Tissue Culture: Theory and Practice . Elsevier.
9. Dixon RA. 2003. Plant Cell Culture. IRL Press.

SEMESTER-II

(Core paper)

Paper Code: 16GEN22C4 **LAB COURSE-III** **Credits: 4**

Time: 6 Hours **(Based on 2C2,2C3&2C3 papers)** **Max. Marks: 100**

SEMESTER-II

DISCIPLINE SPECIFIC (ELECTIVE)

Student will opt any **one** of the given four Discipline specific elective (**2D1 to 2D4)** along with respective **Lab Course-IV(2D5).**

SEMESTER-II

(Discipline specific Elective Paper)

Paper Code: 16GEN22D1 **CONSERVATION BIOLOGY** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit 1
Structure and function of ecosystems; Energy flow and mineral cycling (C,N,P), primary production and decomposition; Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine); Major terrestrial biomes, biogeographical zones of India; Mega-centres of biodiversity; Biodiversity hot spots- Global and Indian; Measurement of biodiversity- species diversity; Concept of centre of origin and crop diversity.

Unit 2
Environmental pollution: Soil, water, air; global climate/environmental change, Role of IPCC; Biodiversity: status, monitoring and documentation, major drivers of biodiversity change, biodiversity management approaches; Factors affecting biodiversity, Global climatic change; Invasive species eroding species diversity; Estimation of genetic diversity, population biology, concept of minimum viable population; Population viability and population genetics to facilitate conservation, Assessing the loss of biodiversity- Floristic surveys/inventory; IUCN Red data book.

Unit 3
Strategies for conservation of biodiversity; *In situ* conservation- Ecosystem approach, Habitat approach, Gene management zones; *In situ*-on farm conservation; *Ex situ* conservation- Whole plant conservation/maintenance, conservation through storage of orthodox seeds at low temperatures; Conservation using *in vitro* culture methods; Conservation using cryobiology; Conservation using storage of DNA molecule; Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).; International organisation supporting conservation (PETA); Indian organisation supporting conservation; International treaties/agreements for conservation; Indian laws for Conservation

Unit 4
Animal Sexual behaviour: Monogamy, Polygamy with examples; Learning Behavior: Habituation, Classical Conditioning, Instrumental Conditioning, Latent Learning, Insight Learning; Communication: visual, acoustic, tactile and chemical communication; Social Behavior: Living In Groups, Agonistic Behavior, Aggressive behaviour Territories and Dominance Hierarchies, Altruism, Reciprocal Altruism, Kin Selection, Parental Care in humans, birds, animals (lion, elephant); Habitat Selection and Optimality in Foraging, Specialists and Generalists; Migration, Orientation And Navigation.

Suggested readings

1. Ecology and Environment by P D Sharma
2. Fundamentals of ecology by E P Odum
3. Essentials of ecology by G T Miller
4. Animal Behavior: An Evolutionary Approach, Tenth Edition by John Alcock
5. http://en.wikibooks.org/wiki/Animal_Behavior
6. http://en.wikipedia.org/wiki/Drosophila_melanogaster

SEMESTER-II

(Discipline specific Elective Paper)

Paper Code: 16GEN22D2 **BIOINFORMATICS & BIOSTATISTICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Introduction to Bioinformatics, Biological Databases: Primary, secondary & specialized databases. Types of databases- Nucleotide sequence database, EMBL, Genebank, Unigene, Genome biology, Protein dBase (Swiss-prot & Trembl and Motif) and 3D structure databases (PDB, SCOP, Cath, Genecards, SRS & Entrez) and various specialized databases like TIGR, Hovergen, TAIR, PlasmoDB, ECDC etc. Sequence retrieval, primer designing for PCR.

Unit-II

Basics of sequence analysis- Dot matrix method, Needleman–Wunsch Algorithm and Smith-Waterman algorithm, Alignments using BLAST and FASTA, Multiple Sequence Alignment (CLUSTAL-X and CLUSTAL-W), Application of multiple sequence alignment (PSSM and Markov/Hidden Markov models. Phylogenetic tree construction by distance based methods, character based methods. Protein Structure Prediction - Ab initio based methods, Homology based methods and comparative modelling, Phylogenetic analysis: Application of phylip.

Unit-III

Methods of data collection, sampling and sampling methods, Sample size estimation and designing of experiments, case-control studies, randomization, replication local control, completely randomized and randomized block design.

Unit-IV

Types of data, tabular and graphical presentation of data; Measurement of central tendency, mean, median, mode, standard deviation, standard error and variance. Analysis of variance (ANOVA), Correlation & regression analysis, tests of significance, t-test, z-test, chi-square test.

Suggested Readings:

1. David W. Mount Bioinformatics: Sequence and Genome Analysis CSHL Press, 2004
2. A. Baxevanis and FBF Ouellette, Bioinformatics: A practical guid to the analysis of genes and proteins 2nd eds. John Wiley 2001
3. Jonathan Pevsner Bioinformatics and functional genomics Ist Ed. Wiley Liss 2003
4. P E Bourne and H. Weissig Structural Bioinformatics Wiley 2003. Statistical Analysis of Non normal data, : J.V. Deshpande, A.P. Gore, A. Shanubhogue, New Age International Publishers Ltd.
5. Introduction to Bioinformatics; T K Attword and DJ Parrysmith (2002) Pearson education.
6. Statistical methods in Animal Sciences, By : V.N. Amble, Indian Society Agricultural Statistics (New Delhi)
7. Statistical Procedure for Agricultural Research : Kwanchai A Gomes Arturo A.Gomez, John Wiley and Sons.
8. A text book of Agricultural Statistics. By: R. Rangaswamy, New Age International Pvt. Ltd.
9. Statistics for Agricultural Sciences. By: G. Nageswar Rao,Oxford and IBH Publishing Co.
10. SP Gupta, Statistical Methods S Chand and Sons 2004.
11. B L Agarwal, Basic Statistics, New Age. 2003

SEMESTER-II

(Discipline specific Elective Paper)

Paper Code: 16GEN22D3 **MEDICAL GENOMICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain short answer eight to ten type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I
Growth and development of medical genetics, Role of genetics in medicine; Diagnostic genetics: Cytogenetics/ Molecular Cytogenetics /Biochemical/Molecular methods; Screening for mutation/ chromosomal anomaly - Adult/Prenatal/Newborn screening; Preimplantation screening (Assisted reproductive technology- *in vitro* fertilization and Embryo transfer); Organ banking, transplantation, Forensic testing - DNA fingerprinting, paternity testing, individual identification.

Unit-II
Treatment of genetic disorders: Recombinant Proteins, Gene therapy: Types, Criteria & technical aspects, Viral vectors, delivery methods and microinjection, germline therapy, gene therapy of (Thalassemia, Cystic fibrosis, DMD), Mitochondrial inheritance disorders (Mitochondrial myopathy, Retinitis pigmentosa,Diabetes mellitus).

Unit -III
Pharmacogenetics: History, Genes involved in pharmacokinetics and pharmacodynamics of drugs, Pharmacogenetic diseases (Hereditary disorders with altered drug response, Malignant hyperthermia, G-6-PD deficiency), Role of functional genomics in new drug discovery and drugable genome, Role of SNPs in drug discovery and development.

Unit-IV
Genetic counseling: Definition and process, Diagnostic problems, decision making, risk assessment and role of genetic counsellors, Prenatal/adult diagnosis of genetic disorders; Psychosocial aspects of genetic counselling. Medical ethics; Risks and benefits; Informed consent and confidentiality Right of choice universability of bioethics; Dilemmas faced by counsellors, Case studies; Genome ownership, Genetic insurance, Genetic privacy, genome Patenting.

Suggested readings:
1. Human Molecular Genetics (2010) 4th ed. - Strachan T. & Read A., Garland Science
2. An introduction to Human Molecular Genetics (1999) - Mechanism of Inherited Diseases Pasternak J. Fitzgerald, Science Press
3. Thompson and Thompson Genetics in Medicine (2007) 7th ed. Robert et al. ,Saunders
4 Landmarks in Medical Genetics – (2002) Ed. Harper P. S., Oxford University Press
5.Chromosome Banding (1990) - Sumner A.T. Unwin, Hyman
6. Genes IX (2009) -Lewin B, Jones and Barlett Publishers

SEMESTER-II

(Discipline specific Elective Paper)

Paper Code: 16GEN22D4 **GENETICS OF MEDICINAL PLANTS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit I

History & philosophics of herbal medicine (Ayurveda, Unani), Importance and need of cultivation of medicinal and aromatic plants; Harvesting, drying, grading and storage of medicinal plants; Organic cultivation of medicinal plants; Good agricultural practices in medicinal plants.

Unit II

Active constituents and uses of important medicinal and aromatic plants: *Asparagus racemosus, Stevia rebaudiana, Aloevera, Withania somnifera, Solanum nigrumi Cassia angustifolia, Rosa damacena, Tagetes minuta, Salvadora species,Cassia tora,Cassia occidentalis,Boerhavia diffusa,Achyranthes aspera,Ncytanthus arborytis,Balanites aegyptiaca,Tridex procumbens* or any other species specific to the region.

Unit III

Molecular biology of plant natural products: Genes involved in biosynthetic pathways of plants, Families of metabolic genes and their evolution (Gene families & their evolution, cytochrome, P450 genes):Expression of metabolism genes; Molecular biology tools used in natural products research; Application of molecular biology approaches to natural products.

Unit IV

Separation and purification of phytopharmaceuticals through thin layer chromatography and column chromatographic techniques; Extraction of essential oils and their evaluation for quality parameters; Natural products and plant biodiversity; Plant cell biotechnology for the production of secondary metabolities, Metabolic engineering of plant secondary metabolism; Molecular farming, Transferring genes from plants to rhizophere microbes and vice-versa.

Suggested Reading

1. Farooqi, A.A. and B.S. Sreeramu (2001). Cultivation of Medicinal and Aromatic Crops. Universities Press (India) Ltd. 3-5-819, Hyderguda, Hyderabad – 29.
2. Handa, S.S. and M.K. Kaul. (1987). Cultivation and Utilization of Medicinal Plants. RRL, Jammu.
3. Kumar, N., J.B. Md. Abdul Khadar, P. Rangaswamy and I. Irulappan. (1982).
4. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

SEMESTER-II

Paper Code: 16GEN22D5 **LAB COURSE-IV** **Credits: 4**

(FOR RESPECTIVE DISCIPLINE SPECIFIC ELECTIVE PAPER)

Time: 6 Hours **Max. Marks: 100**

SEMESTER-III

(Core Paper)

Paper Code: **RECOMBINANT DNA TECHNOLOGY** **Credits: 4**

16GEN23C1

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain short answer eight to ten short type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Principles of Genetic Engineering: Historical account, Components– Nucleic acids, DNA modifying enzymes, Cloning vectors and Cloning hosts, Gene transfer and cloning methods, Gene Screening and isolation - Strategies, DNA libraries, Probe Selection and gene screening.

UNIT II

PCR and DNA sequencing: PCR – Principle, Methodology, Types - RT-PCR, RAPD, AFLP, ISSR, inverse PCR and Real time PCR and their applications,;Sequencing of nucleic acids, DNA sequencing methods - Maxam and Gilbert's method, Sanger's method, Automated DNA sequencing method, Capillary gel electrophoresis for DNA sequencing.

UNIT III

Molecular markers: Type of molecular markers; Application of molecular markers in discerning polymorphism, germplasm characterization, Gene tagging; Disease diagnostics; Marker aided selection in crop improvement. DNA Engineering techniques: Gel electrophoresis of nucleic acids, Methods of labeling of DNA, Blotting of macromolecules: Southern, Northern and Western blotting techniques and hybridization, Oligonucleotide synthesis, Promoter characterization, DNA fingerprinting, Microarray technology, *In vitro* translation.

UNIT IV

Application r-DNA technology: (Production of recombinant protein, Vaccine and pharmaceutical compounds; application in agriculture, Fluorescence in situ hybridization (FISH), Proteomics: Tools techniques, study of protein- protein interaction, protein analysis for gene identification, post translation modification.

Suggested readings:

1. Gene Cloning and DNA Analysis,-An Introduction (2001) Brown T. A., Blackwell Publishing.
2. Gene Cloning and Manipulation- Howe C., Cambridge University Press.
3. Principles of Gene Manipulation and Genomics (2001) - Primrose S. B. & Twyman R. M, Blackwell Publishing.
4. Molecular Cloning (2001) - A Laboratory Manual (3-Volume Set) Sambrook J. et al., CSHL Press
5. Calculations for Molecular Biology and Biotechnology (2003) -Stephenson F. H., Academic Press

SEMESTER-III

(Core Paper)

Paper Code:16GEN23C2 **POPULATION AND EVOLUTIONARY GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-1

Population genetics: Definition & Meaning, Microevolution in Mendelian population: Theory of Allele Frequencies, The Hardy–Weinberg Principle, Applications of The Hardy–Weinberg Principle, Exceptions to Hardy–Weinberg Principle (non-random mating, unequal survival, population sub-division, migration); Natural Selection: Concept of fitness, Natural Selection at the level of gene; Factors affecting gene frequencies: natural selection, genetic drift, mutation; Speciation: Causes of reproductive isolation, Evidence for speciation, Mode of speciation: Allopatric, Parapatric, Sympatric; Co-speciation: sexual selection, Co-evolution and convergent evolution.

Unit- 2

Populations In Genetic Equilibrium: Balancing Selection, Mutation–Selection Balance, Mutation–Drift Balance; Quantitative Genetics: Johannsen pure-line concept; Quantitative traits and their characteristics, threshold traits, multiple factor hypothesis, types of quantitative traits, determining gene number for a polygenic trait, components of phenotypic variation and genetic models for quantitative traits; Concept of heritability: Broad sense heritability and Narrow sense heritability; Predicting phenotypes; Artificial selection.

Unit-3

Emergence of Evolutionary Theory: Lamarckism and Darwin's Theory of Evolution, Shortcomings of Lamarckism and Darwin's Theory; Origin of basic organic monomers and polymers, Spontaneous generation, Louis Pasteur's experiment, Oparin and Haldane's theory of origin of life, Miller-Urey Experiment; Origin of prokaryotes and eukaryotes; Evolutionary time scale: Eras, periods and epoch, Major events in evolutionary time scale. Bioinformatics- Phylogenetic tree construction by distance based methods, character based methods. Phylogenetic analysis: Application of phylip.

Unit-4

Molecular evolution; concept of neutral theory of molecular evolution; Molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification electrophoresis: Principle, procedure and application of- Agarose, PAGE, SDS-PAGE, Pulse field electrophoresis, Paper cellulose acetate and High voltage electrophoresis; Isoelectric focusing (IEF).Genetic Variation in natural populations; Chromosomal and allozyme polymorphism, Balanced polymorphism and heterosis; Protein and nucleotide sequence analysis; Origin of new genes and proteins; gene duplication and divergence.

Suggested Readings:

1. http://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_01
2. http://evolution.berkeley.edu/evolibrary/article/evo_44
3. Principles of Genetics by D. Peter Snustad and Michael J Simmons
4. Genetics: A Conceptual Approach by Benjamin A. Pierce
5. The Science of Genetics by Alan G. Atherly, Jack R. Girton, John F. McDonal
6. Genes in the Environment- Rosie S. Hails, Wiley-Blackwell Publications,

SEMESTER-III

(Core Paper)

Paper Code: GEN23C3 **LAB COURSE-V** **Credits: 4**

Time: 6 Hours **(based on 3C1 & 3C2)** **Max. Marks: 100**

SEMESTER-III

GROUP 1 (D1 TO D 3)

(Discipline specific Elective Paper)

Paper Code: 16GEN23D1 **HUMAN MOLECULAR GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I
Organization of genome in humans: General features of chromosomes, reiterated sequences and their detection: LINE, SINE, Alu family, transposable elements; Gene mapping: Gene mapping by somatic cell hybridization, top down approach to molecular mapping, restriction maps and contig construction (the bottom up approach);Engineering chromosomes : Yeast artificial chromosome, making YACs, MACs (mammalian artificial chromosomes) and satellite DNA's, artificial chromosomes (SAT ACS).

Unit –II
Molecular explanation of dominance & recessiveness, incomplete penetrance & expressivity; Identification of genetic basis of disease: Positional analysis, structural and functional cloning; Bioinformatic analysis; Characterization, Mutation detection, diagnosis and therapy (with examples from autosomal Dominant, autosomal recessive, X-linked dominant, X-linked recessive and complex disease Conditions); Identification of specific disease gene in Huntington's disease, DMD (Duchenne muscular dystrophy) and Cystic fibrosis.

Unit-III
Genetic susceptibility to common diseases: Types and mechanisms of susceptibility; Genetic approaches to common diseases (Diabetes mellitus, Hypertension, Coronary artery diseases, Schizophrenia, Alzheimer's disease); Whole genome association (Single nucleotide polymorphism, CNVs).

Unit-IV
Genetic toxicology: Genotoxicity- classification of genotoxic agents, genotoxic test systems, mutagenicity, teratogenecity; DNA damage & genome instability: endogenous metabolism & DNA damage, exogenous factors (irradiation & carcinogens); Functional genomics: cDNA/gene, cloning; site-directed mutagenesis; Mammalian tissue culture,Methods for generation of transgenic animals/ knock-in, knockout models (microinjection, ES cell transformation); E Numutagenesis; PFGE, Automated DNA sequencing.

Suggested readings:
1. Human Molecular Genetics (2011) 4thed - Strachan T. & Read A., Garland Science
2. An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases
(1999)- Pasternak J. Fitzgerald, Science Press
3. Genetics in Medicine 7th Ed (2007) - Thompson and Thompson, Saunders
4 Landmarks in Medical Genetics (2002) (Ed.) Harper P. S. Oxford University Press
5. Chromosome Banding (1990) -Sumner A.T., Unwin Hyman
6. Human Genetics: Problems and Approaches (1997)- Vogel F. and Motulsky A. G, Springer Verlag

SEMESTER-III

(Discipline specific Elective Paper)

Paper Code: 16GEN23D2 **DROSOPHILA GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instruction for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit.

Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Drosophila as an model organism, Methods for collection from natural sites, Life cycle of *Drosophila* with characteristic features of each stage, Mechanism of sex determination in *Drosophila m.*; mating behavior in *Drosophila*, Basic requirements for setting up *Drosophila* laboratory; Nonallelic and allelic interactions in *Drosophila,* Linkage study, mutants in *Drosophila,* sex lethals in *Drosophila*.

Unit-II

Mutagenesis and isolation of new variants**:** X-ray and chemical mutagenesis, P-element and insertional mutagenesis *Drosophila* development: Embryonic development, Maternal effect genes and formation of body axes, Segmentation genes, Homeotic genes and their functions, Imaginal discs and their types, Pupa and metamorphosis; Induction and development of compound eye in *Drosophila*. Polytene chromosome: Maps, puffing and utility; Chromosomes of *Drosophila*, Balancer chromosomes,

Unit-III

Stem cells in *Drosophila,* Oogenesis in *Drosophila,* Ectopic expression, Generation of Transgenic *Drosophila*: (a) Germ-line transformation, (b) Application of P-element based vectors in transgenic generation; Advancement in *Drosophila* genetics: (a) Mitotic recombination, (b) Somatic clones, (c) Germ-line clones, (d) Conditional and /or targeted expression/ablation of genes/transcripts (e.g. UAS/GAL4 system), (e) RNAi based screening of gene functions in *Drosophila.*

Unit-IV

Drosophila model for human genetic disorders like Parkinson's, Huntington's, Alzheimer's diseases etc.; Brief overview of *Drosophila* genome project: Online databases and other resources for *Drosophila* genetics.

Suggested Readings

1.Principles of Genetics by D. Peter Snustad and Michael J Simmons

2. Genetics: A Conceptual Approach by Benjamin A. Pierce

3. The Development of *Drosophila Melanogaster* Vol. 1 by Cold Spring Harbor Press

4. Matthew C. LaFave, Jeff Sekelsky. Mitotic Recombination: Why? When? How? Where? PLoS Genetics March 2009 | Volume 5 | Issue 3 | e1000411

5. David A. Elliott and Andrea H. Brand. The GAL4 System: *A Versatile System for the Expression of Genes* from Methods in Molecular Biology: Drosophila: Methods and Protocols

SEMESTER-III

(Discipline specific Elective Paper)

Paper Code: 16GEN23D3 **SOMATIC CELL GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instruction for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Structure and organization of animal cell; Equipments and materials for cell culture technology; Introduction to the balanced salt solution and simple growth medium, Role of carbon dioxide, Role of serum and supplements, Serum & protein free defined media and their application.

Unit- II

Primary culture, secondary culture, serum free culture and established cell line cultures; Measurement of viability and cytotoxicity; Biology and characterization of the cultured cells, measuring parameters of growth, Basic techniques of mammalian cell culture *in vitro*, disaggregation of tissue, maintenance of cell culture, cell separation, cell synchronization, Scaling-up of animal cell culture; Organ and histotypic cultures.

Unit-III

Biology and genetics of stem cells- definition & characteristics of stem cell; Sources and origin of stem cell, types of Stem cells, nature of pleuripotent cells, division; Hematopoitic stem cells, Neural stem cells, Adult & embryonic stem cell, Cancer stem cell; Cell based therapy, Therapeutic cloning, Bone marrow transplantation versus Stem cell transplantation and GVHD; Epidermis & its renewal by stem cell.

Unit-IV

Somatic cell fusion and somatic cell genetics; Tissue and organ culture - advantages and limitations; medical/pharmaceutical products of animal cell culture; Monoclonal antibodies, Cell culture based vaccines, Hybridoma technology etc., Genetic engineering of animal cells and their applications; Artificial life.

Suggested readings

1. Freshney I. Culture of Animal Cells: A Manual of Basic Technique, 5th Edition Publisher: Wiley-Liss, 2005 ISBN: 0471453293.
2. Nigel Jen, Animal Cell Biotechnology:Methods and protocols, Humana Press.
3. R. Lanza, J. Gearhart et al (Eds), Essential of Stem Cell Biology. (2009), Elsevier Academic press.
4. Stein et al. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual. Wiley-Blackwell; 1 edition (January 4, 2011).
5. Lanza et al. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1).Academic Press (September 28, 2004)

SEMESTER-III

GROUP II (D 4 TO D 6)

(Discipline specific Elective Paper)

Paper Code: 16GEN23D4 **PLANT MOLECULAR GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I
Gene expression in plants:Gene structure ,expression and regulation in plants- an overview of nuclear & organelle gene structure, function and expression with emphasis on aspects that are unique to plants genes; Development of Arabidopsis as a model for molecular genetic studies in plant biology.

Unit-II
Use of *in vitro* culture technology: Micro-propagation for multiplicaion; Embryo rescue for production of hybrids; Production of haploid through anther or pollen culture; Culture and manipulation of protoplast-Somatic Hybrids, Organelle transfer and cybrids; *In vitro* screening and selection of desirable cell lines; Creation of soma-clonal variation and selection of desirable genotypes in genetic improvement; *In vitro* mutagenesis; Callus and cell culture for production secondary metabolites; Production of synthetic seed; Germplasm conservation.

Unit-III
Genetic Transformation: Plant transformation vectors- T-DNA, viral vectors, transposon elements; Genetic transformation methods: Agro-bacterium system; Direct DNA transfer by ballistic gun method, electro-proration, microinjection; Alternate in-plant methods, floral dip, silicon carbide, pollen tube pathway etc.; Marker-free and novel selection strategies; Gene silencing; RNA interference (RNAi) system; Gene knockdown.

Unit-IV
Application of technology and bio-safety; Targeted transfer of genes conferring resistance to biotic and abiotic stresses, nutritional quality, and other desirable traits, like male sterility, flowering, fruiting, ripening etc. (case study); Concerns about bio-safety of genetically modified organism (GMO) (Allergen, toxicity, impact on biodiversity etc.); Indian regulatory system for testing of GMOs in laboratory, field trials and commercial release of transgenic; Bio-confinement strategies for cultivated crops; bio-safety and ethics in generating GMOs; potential benefits of GMOs.

Suggested readings:
1. Plant Tissue Culture- Theory and Practice (1996) Bhojwani S. S. & Razdan M. K., Elsevier
2. Plant Biotechnology-The Genetic Manipulation of Plants (2003) Slater A. Scott N. & Fowler M., Oxford University Press Inc.
3. Plants, Genes and Crop Biotechnology (2003) - Chrispeels M. J. & Sadava D. E., Jones and Barlett Publishers
4 Principles of Gene Manipulation and Genomics (2001) -Primrose S. B. &Twyman R M, Blackwell Publishing.
5. Plant Cell, Tissue and Organ Culture- Fundamental Methods (1995) (Eds). Gamborg O. L & Phillips G. C. Springer-Verlag.
6. Plant Biotechnology (2006) - B. D. Singh, Kalyani Publishers.
7. Plant Cell Culture- A practical approach - (1985) Dixon RA (ed.) IRL Press, Oxford, Washington, DC

SEMESTER-III

(Discipline specific Elective Paper)

Paper Code: 16GEN23D5 **MICROBIAL TECHNOLOGY** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit -I
Microbial innovations in pharmaceutical, health, agricultural and industrial sectors; Strategies for selection and improvement of industrial strains of microorganisms; Metagenomics of the isolation of genes for novel compounds; Measurement and control of bioprocess parameters; Genetic and Environmental Control of metabolic pathways.

Unit- II
Process Development: optimization of bio-process development, classical and statistical methods of optimization, different matrices, whole cell and enzyme immobilization, scale up of bioprocess, general concepts of fermenter. batch, fed and continuous fermentation.

Unit -III
Downstream process, purification and characterization of industrially important microbial products; Primary and secondary metabolites; Industrial production of antibiotics, biofuel, steroids and single cell proteins; Peptide antibiotics of bacteria and its role to combat antimicrobial resistance.

Unit- IV
Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression system, limitations of metabolic engineering. Metabolic engineering of antibiotics. Maintenance and containment of recombinant molecules.

Suggested readings:

1. Biotechnological Innovations in Chemical Synthesis: BIOTOL, Butterworth - Heinemann.
2. Industrial Microbiology, G. Reed (editor), CBS Publishers (A VI Publishing Company).
3. Genetics and Biotechnology of Industrial Microorganisms. C.L. I-le'-shnergev, S.W. Queener and Q Hege^n. American Society of Microbiology.
4. Protein Expression A Practical Approach: Edited by S.J. Higgins and B.D. Hames (OUP).

SEMESTER-III

(Discipline specific Elective Paper)

Paper Code: 16GEN23D6 **RNAi AND ITS APPLICATIONS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter

There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit-I

Discovery of RNA interference, Categories of small non-coding RNAs: dsRNAs, siRNAs, shRNAs, piRNAs and miRNAs, Different components of gene silencing (Dicer,Guide RNA and RNA- induced silencing complex, Translation initiation factor, RNA dependent RNA polymerase,Transmembrane protein), Mechanism of RNA interference (Processing of dsRNA in to siRNAs, amplication of siRNAs, degradation of mRNA). Bacterial vectors for RNAi delivery.

Unit-II

Micro-RNA: Identification and biogenesis, Apoptosis-related micro-RNA, kinship of si RNA and Micro-RNA related pathways, functional classifications ,Large-scale genetic analysis using RNAi: Genome-wide RNAi screens in *C. elegans*, and other systems. , siRNA vectors, siRNA delivery *in vitro* and *in vivo*; RNAi in mammalian cells: Searching for right siRNA, getting siRNA into cells and verification for specificity.

Unit-III

RNAi to gene function: (Signal transduction, cell cycle regulation, development, cell motility, cell death, viral invasion/replication) ,RNAi interactomics and therapeutics informatics – RNAi libraries, discovering RNAi genes and role of bioinformatics, interactomics of RNAi, database and prediction tools of miRNA, siRNA.

Unit-IV

Expression of dsRNA in animals and plants and its applications: RNAi microarrays (Loss of function genetics in mammalian cells);Recent developments and applications in agriculture, Applications of , RNAi therapy: RNAi and therapeutics,(cancer, infectious diseases, cardiovascular and cerebrovascular diseases, neurogenerative disorder, Future of RNAi in biology and medicine.

Suggested readings:

1. The RNA World – (2006) 3rd Eds. T Gesteland et al., CSHL Press
2. RNA Interference Technology- From Basic Science to Drug Development. Eds. Fire et. al. Cambridge University Press,
3. RNAi: A Guide to Gene Silencing (2003).-Ed. Gregory J. Hannon, CSHL Press
4 RNA Silencing: Methods and Protocols (2005) --Ed. Gordon G. Carmichael, CSHL Press
5. RNA Interference in Practice (2005) - Ed. Ute Schepers, Wiley-VCH GmbH & Co. KGaA.
6. Genes IX (2009) -Lewin B, Jones and Barlett Publishers

SEMESTER-III

Paper Code: 16GEN23D7 **LAB COURSE-VI** **Credits: 4**

(FOR RESPECTIVE TWO DISCIPLINE SPECIFIC ELECTIVE PAPERS)

Time: 3 Hours **Max. Marks: 100**

SEMESTER-III

INTERDISCIPLINARY/OPEN ELECTIVE COURSE

(FROM COMMON POOL)

The students are required to take one paper (Interdisciplinary/Open Elective) of their choice from any other Subject/Department of M.D. University campus Rohtak/ from pool of papers provided by the university

Paper Code: to be written as per student option/ choosen I.D paper
Time: 3 Hours

Credits: 3
Max. Marks: 100

SEMESTER-IV

(Core Paper)

Paper Code :16GEN24C1 **SOCIAL, ETHICAL ISSUES IN GENETICS** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit- I
Concept of IPR, Protection of intellectual property, World organizations, forms of protection- Copyright, Trademark; Geographical indications, trade secrets, Layout design of integrated circuits; Human genome and IPR, Issues on IPR in Public-Private partnership. Intellectual property rights and biotechnology.

Unit- II
Patent: Criteria and procedure of patenting, patenting biological material; Patent procedure in India; Patenting basmati rice in USA, revocation of turmeric and neem patent; Patenting of biological material with example and case studies. Patentability of life forms with special reference to microorganisms, pharmaceutical industries, biodiversity, naturally occurring substances. Availabilities of Patent facilitating funds, Substantive Patent Law Treaty (SPLT), Word patent, European Patent.

Unit -III
Ethical decision making, ethical dilemmas, professional ethics- professional conduct; Somatic and germ line gene therapy, clinical trials, the right to information; International ethical guidelines for biomedical research involving human subjects (C10MS-WHO) ethics committee function; Social and ethical issues in human stem cell research. Religious considerations in stem cell therapy. Genetic discrimination, insurance and employment.

Unit -IV
Planning, Organizing, Leading & Controlling; Concepts and characteristics of information; Importance of Management Information System (MIS); Overview of reprogenetics, Consumer genetics, Personal genomics, Public health genetics, Community genetics, Regenerative medicine; Drugs & Cosmetics Act, The Patents Act, The Medical Termination of Pregnancy Act, The Preconception & Prenatal Diagnostic Techniques Act, The Transplantation of Human Organs Act, Human Cloning.

Suggested Readings:

1. Biological Diversity Act, 2002 and Biological Diversity Rules, National Biodiversity Authority, Chennai, 2004, pages 57.
2. Gautam PL and Singh AK 1998 Agrobiodiversity and Intellectual Property Rights (IPR) related issues. *Indian J. Pl. Genet. Resources* 11:129-153.
3. Khetarpal PL 2004. A critical appraisal of seed health certification and transboundary movements of seeds under WTO regime. *Indian Phytopathology* 57:408-427.
4. Plant Biotechnology, Dr. Chawla, for IPR.
5. Department of Biotechnology, Ministry of Science & Technology, Government of India, Ethical policies on Human Genome, Genetic Research and Services (www.dbtindia.nic).

SEMESTER-IV
(Core Paper)

Paper Code: 16GEN24C2 **LAB DESIGN AND BIOSAFETY** **Credits: 4**

Time: 3 Hours **Max. Marks: 80**

Instructions for paper setter
There will be a total of nine questions. Question No. 1 will be compulsory and shall contain eight to ten short answer type questions without any internal choice and it shall cover the entire syllabus. The remaining eight questions will include two questions from each unit. Candidates will be required to attempt one question from each of the four units. They will attempt five questions in all.

Unit 1
Introduction, trends, risk classification of laboratory, design & safety guidelines for biosafety level I, II, III and IV laboratories, Laboratory animal facility. Laboratory space planning; Engineering Considerations: Electrical (Emergency power, power requirements, lighting), Mechanical (Heating, Ventilating, and Air Conditioning); Plumbing, Energy Conservation in lab.; Concerns Specific To Research Facilities: Finishes, Doors and hardware, Furniture, Glassware washers and Dryers, Reagent Grade Water Systems; Preparation rooms and storage, The greenhouse and animal house; Security, Life management: Eye wash and related facilities, Fire prevention and control measures.

Unit 2
Handling & Storing of hazardous chemicals, Chemical incompatibility, Chemical Storage Locations , Material safety data sheet and its significance; Disposal of chemical waste: Restrictions, Waste containers, Labels, Storage of waste chemicals, Scheduling of waste collection, Segregation of incompatible chemical wastes; Disposal of biological waste: Sharps, culture stocks and labware, animal body parts, animal solid waste, animal liquid waste etc; Radioactive waste management

Unit 3
A Historical perspective of bio-safety; Definition, requirement, biosafety containment facilities, biohazards colour coding: **Biosafety Requirements:** Registration for the Use of Biological Materials, Human pathogens, Human Blood, Body Fluids, Tissue and Other Potentially Infectious Materials.

Lab Equipments and Precautions for using: HEPA filters, Biological Safety Cabinets (BSCs), Use & care of pipettes, pipetteguards, syringes and needles, Centrifuges, Oven, Incubators, Sonicators, and Cell Disruption Equipment, Microtome/cryostat, Microincinerators, Miscellaneous Equipment (Waterbaths, Cold Storage, Shakers); Lab animals; Decontamination and Disposal Procedures; Transportation of Infectious Substances.

Unit 4
Risk Assessment and Risk Management; Routes of Exposures, Exposure incidents and their types; Emergency Procedures for Exposure Incidents, Emergency procedure for fire & chemical exposure, safety check list.

Medical Surveillance Program and their significance: Tuberculosis (TB) Screening and Immunizations; Medical Restrictions: Pregnancy, Reproductive Biological Hazards, Other Restrictions; Objectives of Housekeeping in laboratory; Bio-safety levels for different infectious agents and infected food/animals, routes of transmission & protection measures; Laboratory Practices for different biosafety levels, Biosafety training programs.

Suggested Readings:
1. **Biosafety in Microbiological and Biomedical Laboratories** 5th edition by U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institutes of Health
2. **Biological Safety Manual** by Yale University
3. **RESEARCH LABORATORY Design Guide** by Department of Veterans Affairs, United States of America
4. **Laboratory Safety Manual** – the University of North Carolina at Chapel Hill
5. **WHO (2003)- Laboratory biosafety manual** WHO, Geneva.

SEMESTER-IV

(Core Paper)

Paper Code:16GEN24C3 **Dissertation*/Project */Field work*** **Credits: 20**

Time: 6 Hours **Max. Marks: 300**

***M.Sc. Dissertation rules**

Distribution/Allotment of Students to be done at department level in the 3rd semester
The dissertation to be innovative work based on small piece of research with duration in 4th semester.
Scheme of chapters of dissertation is as follows-
Acknowledgement
Certificate by candidate& countersigned by allotted Supervisor

i) Introduction with objectives
ii) Review of literature(Brief)
iii) Material & Methods
iv) Results
v) Discussion
vi) Summary
vii) Bibliography

Pattern of References/typing/figures as per Ph.D. Thesis. Last date of submission will be 30th June. Evaluation of dissertation will be done by external examiner from panel approved by PGBOS and internal examiner. Final marks will be mean of internal + external.

The written part of dissertation report shall account for 250 of marks and the viva-voce will be conducted by a duly constituted Board of Examiners for the remaining 50 of marks.

No. of copies of Dissertations will be for Deptt. Record, one copy of guide record, one copy for candidate and soft copy to library. Any patent/IPR based on Dissertation will be in the name of MDU student & Guide as inventer.Publication based on dissertation will be under control of Guide.