MSc GENETICS I YEAR
SEMESTER – I
(Proposed Scheme for Academic year 2019 onwards)

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G101T	Principles of Inheritance	4	4	20	80	100
2.	G102T	Cell Biology & Cytogenetics	4	4	20	80	100
3.	G103T	Fundamentals of Biochemistry	4	4	20	80	100
4.	G104T	Biostatistics and Population Genetics	4	4	20	80	100
PRACTICALS							
1.	G151P	Principles of Inheritance	2	4		50	50
2.	G152P	Cell Biology & Cytogenetics	2	4		50	50
3.	G153P	Fundamentals of Biochemistry	2	4		50	50
4.	G154P	Biostatistics and Population Genetics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER – II

S. No	Syllabus Ref. No	Papers	Credits	Teaching Hours/ week	Marks		
					Internal Assessment	Semester Exam	Total
1.	G201T	Genome organization and maintenance	4	4	20	80	100
2.	G202T	Gene expression and regulation	4	4	20	80	100
3.	G203T	Plant Genetics and Molecular Breeding	4	4	20	80	100
4.	G204T	Human Genetics	4	4	20	80	100
PRACTICALS							
1.	G251P	Genome organization and maintenance	2	4		50	50
2.	G252P	Gene expression and regulation	2	4		50	50
3.	G253P	Plant Genetics and Molecular Breeding	2	4		50	50
4.	G254P	Human Genetics	2	4		50	50
		Total	**24**	**32**			**600**

MSC GENETICS II YEAR
SEMESTER - III

SN	Syllabus Ref. No	Papers	Credits	Teaching hours/ week	Marks		
					Internal assessment	Semester exam	Total
1.	G301T	Genetic Engineering	4	4	20	80	100
2.	G302T	Immunogenetics	4	4	20	80	100
3.	G303T	**ELECTIVE 1**: **A.** Human Genomics & Medical Genetics (or) **B.** Animal Genetics & Mouse Models	4	4	20	80	100
4.	G304T	**ELECTIVE 2**: **A.** Plant Genomics & Biotechnology (or) **B.** Plant Nutraceuticals & Nutrigenomics	4	4	20	80	100
PRACTICALS							
1.	G351P	Genetic Engineering	2	4		50	50
2.	G352P	Immunogenetics	2	4		50	50
3.	G353P	**A.** Human Genomics & Medical Genetics (or) **B.** Animal Genetics & Mouse Models	2	4		50	50
4.	G354P	**A.** Plant Genomics & Biotechnology (or) **B.** Plant Nutraceuticals & Nutrigenomics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER- IV

S No	Syllabus Ref. No	Subject	Credits	Teaching Hours	Marks		
					Internal Assessment	Semester Exam	Total
THEORY							
1.	G401 T	Bioinformatics	4	4	20	80	100
2.	G402 T	Applied Microbial Genetics	4	4	20	80	100
3.	G403 T	**Elective** 3A. Cell and Tissue Engineering (OR) 3B. Genetic Toxicology	4	4	20	80	100
4.	G404 T	Project work	4	4			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	Cell and Tissue Engineering (OR) Genetic Toxicology	2	4		50	50
4.	G 454 P	Project Thesis Presentation	2	4		50	50
		Total	**24**	**32**			**600**

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER- I
G301T: GENETIC ENGINEERING

1.Course Objectives (C.Obj)

a. To learn about the basic components of molecular cloning
b. Understand molecular techniques related to genetic engineering
c. To learn nucleic acid and protein blotting techniques
d. To comprehend latest molecular biology techniques and their applications

2. Course Outcomes (C.O)

e. Understanding the fundamentals of cloning processes and components involved
f. Comprehension of various molecular biology techniques and their applications
g. Acquaintance with recombinant DNA and DNA sequencing techniques
h. Knowledge regarding the use of rDNA techniques in modern biology, medicineand agriculture

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Enzymes and vectors for molecular cloning**	
1.1	Properties and applications of DNA modifying enzymes - restriction endonucleases & types (Type I to type IV); host-controlled restriction modification system, isoschizomers	3
1.2	Modifying enzymes- methyltransferases, polymerases, kinases, phosphatases, nucleases, terminal transferase and ligases	3
1.3	Cloning vectors- properties of cloning vectors	2
1.4	Types of cloning vectors - plasmids, lambda-based vectors and derivatives (insertion vectors, replacement vectors, cosmids, phasmids & phagemids); plant transformation vectors- Ti, Ri plasmids	3
1.5	High-cloning capacity vectors- single stranded DNA vectors (M13),YACs, BACs, PACs	3
1.6	Hosts used in genetic engineering, prokaryotic hosts- Escherichia coli, Bacillus subtilis ; Eukaryotic hosts –Yeast	2

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Cloning Strategies**	
2.1	Generalized cloning strategies: Generation and purification of vectors and inserts, restriction digestion, modification and ligation, transformation of bacteria, screening of positive clones	2
2.2	Strategies for construction of genomic libraries: selection of vectors, screening methods	3
2.3	Positional cloning (chromosome walking & chromosome jumping)	3
2.4	Construction of subtractive and normalized cDNA libraries & its advantages	3
2.5	PCR : Principle ,primer design – gene specific primers, nested primers, degenerate primers, optimization of PCR components and thermal conditions	3
2.6	Types of PCR – inverse PCR, nested PCR, RACE-PCR	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Selection and screening of recombinant clones**	
3.1	Genetic selection- insertional inactivation and alpha complementation	2
3.2	Principle of hybridization- northern, southern & western blotting, dot-blot & colony hybridization, colony PCR	3
3.3	Labeling of nucleic acids- end labeling [3′-& 5′-], random priming & nick translation using radioactive & non-radioactive probes	2
3.4	Immunological screening, screening by hybrid arrest and hybrid released translation	2
3.5	Isolation of individual genes by complementation assay & contig assembly	3
3.6	DNA sequencing methods- Maxam-Gilbert and Sanger's method, automated sequencing, multiplex sequencing, Next Generation Sequencing (principle & its applications)	4

Unit Number	Topics to be covered
UNIT 4	**Analysis of gene expression and genetic manipulation**
4.1	Mapping of restriction sites, S1 mapping, qRT-PCR, microarrays and RNAseq
4.2	Site directed mutagenesis: primer design, PCR-based method and screening for mutants
4.3	Gene silencing technology, anti-sense, siRNA, microRNA
4.4	Transgenic technology: construct design and cloning, electroporation, screening, microinjection and genotyping; applications
4.5	Gene knock-in & knock-out technologies: methodology and applications
4.6	Applications of genetic engineering in agriculture, animal husbandry, medicine & industry

PRACTICALS

G351P: GENETIC ENGINEERING

S. No.	Topic to be covered	No. of hours
1	Isolation of plasmid DNA	4
2	Restriction digestion and gel electrophoresis	4
3	Preparation of competent cells	4
4	Genetic transformation and selection of recombinant clones	4
5	Polymerase chain reaction	4
6	Site-directed mutagenesis	4
7	Restriction mapping problems	4
8	DNA sequence analysis problems	4

REFERENCE BOOKS

1. Principles of Gene Manipulation and Genomics- Sandy B. Primrose, Richard Twyman 7thEdition; Blackwell Publishing
2. Gene Cloning and DNA Analysis: An Introduction- T. A. Brown- John Wiley & Sons
3. An Introduction to Genetic Engineering- Desmond S.T. Nicholl-Cambridge UniversityPress
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA- Bernard R.Glick, Jack J. Pasternak, Cheryl L. Patten - ASM Press

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER- II
G302T: IMMUNOGENETICS

1. **Course Objectives (C.Obj)**
   a. To provide insights on immune responses & organization of the immune system
   b. To understand the basic concepts of immunoglobulins structure and functions.
   c. To give an overview on structure and functions of Major Histocompatibility Complex
   d. To unravel the importance of the cell mediated immune responses and its implications on autoimmunity & immunodeficiency disorders.
2. **Course Outcomes (C.O)**
   a. Able to comprehend the significance of the immune system
   b. The role and therapeutic implications of immunoglobulins can be known
   c. Gains knowledge on the importance of MHC & its role in organ transplantation
   d. Identifies the role of cell mediated immune responses and creates awareness aboutautoimmune and immunodeficiency disorders.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT- 1	**Basic principles and overview of the immune System**	
1.1.	Types of immunity: innate immunity- anatomic, physiological, phagocytic barriers; inflammation, anti-microbial substances; Acquired immunity and its characteristic attributes	3
1.2.	Cells of the immune system- lymphoid cells (B & T lymphocytes; T-cell sub-sets; NK cells), mononuclear phagocytes (monocytes, macrophages), granulocytes (neutrophils, eosinophils, basophils, mast cells & dendritic cells)	3
1.3.	Organs of the immune system- primary lymphoid organs (bone marrow & thymus); secondary lymphoid organs (lymph nodes, spleen and mucosal-associated lymphoid tissue, cutaneous associated lymphoid tissue)	3
1.4.	Antigens- immunogenicity versus antigenicity, factors that influence immunogenicity	2
1.5.	Epitopes- properties of B-cell and T-cell epitopes; Haptens and the study of antigenicity, haptens and hapten-carrier conjugates	2
1.6.	Vaccines- Immunization(Passive& Active) types of vaccines (Live, Attenuated; Inactivated or “Killed” vaccines; Subunit vaccines; Recombinant vector vaccines; DNA &conjugate vaccines) Adjuvants	3

Unit Number	Topics to be covered	No. of lectures
UNIT-2	**Immunoglobulins- Structure and Functions**	
2.1.	Basic structure of immunoglobulins; role of multiple myeloma in understanding Ig structure; fine structure of immunoglobulins- immunoglobulin domains – variable region and constant region domains	3
2.2.	Effector functions of immunoglobulins– APCC, complement, neutralization, opsonization, Immunoglobulin classes- IgG, IgM, IgA, IgD & IgE; Structure & functions of Ig classes, Generation of antigenic determinants on Immunoglobulins	2
2.3.	Organization and expression of immunoglobulin light and heavy chain genes- antibody diversity	4
2.4.	B-cell activation & proliferation by thymus- independent & thymus-dependent antigens, invivo sites for induction of humoral response; B cell differentiation, class-switching and generation of plasma cells and memory cells	4
2.5.	Generation of polyclonal antibodies and applications (immunosupression & rabbit antithymocyte globulin); Generation of monoclonal antibodies and applications (abzymes, immunotoxins & monoclonal imaging)	2
2.6.	B cell immunodeficiency disorders- X-linked agammaglobulinemia, selective immunoglobulin deficiency	1

Unit Number	Topics to be covered	No. of lectures
UNIT-3	**Major Histocompatibility Complex**	
3.1.	General organization and inheritance of MHC- organization of MHC class I & II genes, MHC haplotype	2
3.2.	Structures of MHC class I and II molecules; peptide binding of MHC molecules	4
3.3.	MHC molecules- cellular distribution & immune responsiveness	3
3.4.	Polymorphisms of MHC class I and II molecules and its implication in diseases	2
3.5.	Transplantation- relation between donor and recipient; types of grafts; bone marrow & hematopoietic stem cell transplantation	2
3.6.	Human leukocyte antigen (HLA) typing by mixed lymphocyte reaction (MLR) & microcytotoxicity tests; Role of HLA typing in organ transplantation.	3

Unit Number	Topics to be covered	No. of lectures
UNIT-4	**T- Cell- mediated immune responses**	
4.1	Antigen processing and presentation by antigen presenting cells: endogenous antigens- cytosolic pathway; exogenous antigens- endocytic pathway ; Presentation of Nonpeptide Antigens	3
4.2.	Structure and functions of T-cell receptor; T-cell receptor complex (TCR-CD3, T-cell accessory molecules), Ternary TCR-Peptide-MHC complex	3
4.3.	Cell-mediated immune response: General properties of effector T cells, cytotoxic T cells ,generation of effector CTLs, CTL mediated killing of target cells--Granzyme and Perforin Mediated Cytolysis& Fas-FasL Mediated Cytolysis; Experimental assessment of cell mediated cytotoxicity- MLR, CML, GVH	4
4.4.	Cytokines- general properties & biological functions; Cytokine secretion by TH1 & TH2 subsets, Cytokine antagonists; Delayed-type hypersensitivity–Sensitization & Effector phases and cytokines involved in DTH	2
4.5.	Autoimmunity and mechanisms of auto-immune disorders-Insulin dependent diabetes mellitus (IDDM), Rheumatoid Arthritis (RA) and Systemic Lupus Erythematosus (SLE)	2
4.6.	Immuno-deficiency disorders- Congenital Immunodeficiency disorders (Severe combined Immunodeficiency (SCID), Digeorge Syndrome); Acquired Immunodeficiency Disorders (AIDS)	2

PRACTICALS

G352P: IMMUNOGENETICS

S.No.	Topics to be covered	No. of Hours
1	ABO blood typing assay	4
2	Microhaemagglutination	4
3	Single Radial Immunodiffusion	4
4	Isolation of lymphocytes and cell viability assay	4
5	ELISA	4
6	HLA typing by PCR	4
7	Western Blot	4
8	FACS	4

REFERENCE BOOKS

1.Kuby Immunology by JA. OwenJ Punt SA. Stranford:
Publ:Freeman.2.Essential Immunology by I. Roitt, Publ:Blackwell
3. Immunology by G. Reever&I.Todd, Publ:Blackwell
4. Immuno diagnostics by S.C.Rastogi, Publ:New Age
5. Fundamental immunology by William E.Paul
6. Text book of immunology by Baruj Benacerraf

MSc GENETICS II YEAR SEMESTER- III
THEORY PAPER- III: ELECTIVE 1(A)
G303T: HUMAN GENOMICS AND MEDICAL GENETICS

1. **Course Objectives (C.Obj)**
   a. To learn the human genome organization and HGP
   b. To understand the molecular mechanisms in the pathology of genetic diseases
   c. To study the importance of genetic counseling and screening
   d. To learn different approaches to therapy for genetic diseases

2. **Course Outcomes (C.O)**
   a. Able to understand the organization of the human genome & the progress made byHGP
   b. Gains knowledge regarding the molecular mechanisms of genetic diseases
   c. Knows the significance of genetic testing and counseling in prevention, diagnosis &management of genetic diseases
   d. Imparts knowledge regarding therapeutic strategies for genetic diseases

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Human Genomics**	
1.1	Human genome architecture: Nuclear genome- Gene number, Gene density, Gene size, Highly Repetitive sequences-Heterochromatin & transposons (LTR & DNA transposons, SINES, LINES)	3
1.2	Gene families: Gene duplication mechanisms; Histone gene cluster, Hemoglobin gene cluster; Pseudogenes; Gene superfamilies	2
1.3.	Human mitochondrial genome: organization, gene mutations and mitochondrial diseases (LHON, MELAS)	2
1.4.	Analysis of gene variants: PCR-based methods for genotyping (PCR-RFLP, ARMS, SSCP, Multiplex PCR),SAGE, Small RNA sequencing	3
1.5.	Human genome project: Goals, strategies, accomplishments and ethical considerations; Progress of genome projects-. 1000 Genome project, HapMap project, ENCODE project; Applications- Clinical genomics, Nutrigenomics	3
1.6.	Functional Genomics: Transcriptomics, Epigenomics and Proteomics; Identification of human genome variations via whole genome, exome, transcriptome and epigenome analyses	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Molecular pathology and genetic diseases**	
2.1	Molecular explanation for dominance and recessiveness, penetrance and expressivity, pleiotropism	3
2.2	Molecular mechanisms for X-chromosome inactivation, Genomic imprinting, Uniparental disomy and Mosaicism	3
2.3	Loss of function mutations: In coding sequences (β-Globin gene); Splice junction mutations – Acceptor and Donor splice site mutations – *DMD, NF1and CFTR*	2
2.4	Gain of function mutations: Dominant –ve effect (collagen gene mutations); Gene dosage effect (*PMP22* gene)	2
2.5	Pathogenic potential of Repeated Sequences: Dynamic mutations – Mechanisms of Trinucleotide expansion (HD, FSX, MD)	2
2.6	Molecular mechanisms of Cancer: Oncogenes, Tumor suppressor genes, Cell cycle dysregulation in cancer, Instability of the genome; Inter and intratumor heterogeneity; Hallmarks of cancer	4

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Genetic counseling and screening for diseases**	
3.1	Genetic counseling and risk assessment, need for genetic testing, levels of genetic testing	3
3.2	Prenatal screening: Indications; Invasive and Non-invasive techniques; Detection of cytogenetic, biochemical and genetic defects in fetal samples	3
3.3	Neonatal Screening: PKU, Galactosemia, SCA & Congenital hypothyroidism	2
3.4	Preclinical screening: Adult onset diseases -Alzheimer's, HD & FHCL, Disease susceptibility for complex diseases - CAD&T2DM	3
3.5	Heterozygote detection and population screening: Thalassaemias, Cystic Fibrosis, DMD, Fragile– X syndrome, Hemophilia	3
3.6	Markers for disease diagnosis and prognosis: Genetic markers; Protein/enzyme markers and antibodies; Use of biosensors and nanoparticles	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Therapy for Genetic Diseases**	
4.1	Conventional methods for treatment of genetic diseases: Diet replacement, dietary avoidance, protein/enzyme substitution; Recombinant gene products for therapy	2
4.2	Gene therapy: Criteria for gene transfer- *invivo*, *invitro* & *exvivo* strategies; Somatic cell gene therapy vs Germ line gene therapy; Gene transfer methods for therapy-Viral vectors, physical and chemical methods; Limitations of gene therapy	3
4.3	Approaches for Gene therapy: Gene Augmentation Therapy, Anti sense therapy, Gene editing, Direct &Indirect cell killing, Microencapsulation	3
4.4	Clinical trials: Adenosine Deaminase deficiency , FHC, CF and Solid tumors	2
4.5	Immunotherapy: Approaches in immune therapy -use of Monoclonal antibodies, NK cells, Dendritic cells, B-lymphocytes and vaccines	3
4.6	Nanomedicine: Therapeutic applications of nanoparticles, medical nanobiosensors; Pharmacogenetics: G6PD & CYP2D6, benefits of Pharmacogenomics	3

PRACTICALS

G 353 P (1A): HUMAN GENOMICS AND MEDICAL GENETICS

S.No.	Topics to be covered	No. of Hours
1.	Genotyping of selective markers – RFLP	4
2.	Genotyping using VNTR markers	4
3.	Genotyping/ Mutation screening by ARMS PCR	4
4.	Problems on Genetic counseling and risk assessment	4
5.	Detection of Trinucleotide repeat expansions (FXS/ HD)	4
6.	Heterozygote detection and screening for Thalassaemias/Hemophilia	4
7.	Detection of BCR-ABL gene mutation in CML	4
8.	Maternal serum testing for prenatal diagnosis	4

REFERENCE BOOKS

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

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER- III: ELECTIVE 1(B)
G303T: ANIMAL GENETICS AND MOUSE MODELS

1. **Course Objectives (C.Obj)**
   a. To identify the significance of chromosomes, sex determination, quantitativegenetics and testing of disorders in different animals of animal husbandry
   b. To familiarize with the role of markers, genetic resources, assisted breeding andtransgenic animals in animal husbandry research
   c. To know the animal cell culture practices
   d. To appreciate the use of mouse as model system for biomedical research

2. **Course Outcomes (C.O)**
   Able to use and handle animals in research and farm studies for genetics andbreeding
   a. Student can practice and handle assisted breeding methods and generate transgenic animals
   b. Able to acquaint skills in handling cell cultures
   c. Able to handle mouse models in biomedical research laboratory

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Animal Genetics & Breeding**	
1.1	Chromosomes-special type of chromosomes, chromosome number– livestock, laboratory animals, birds.	2
1.2	Meiosis and gametogenesis -chromosomes and sex determination	2
1.3	Quantitative genetics–values and means; variance;resemblance between relatives;heritability and repeatability, genetic and phenotypic correlations.	3
1.4	Systems of mating: Inbreeding–relationship coefficients; outcrossing and cross breeding	3
1.5	Gene mapping in livestock–methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques-FISH, somatic cell hybridization, radiation hybrid maps, in-situ hybridization	3
1.6	Animal breeding genetic disorders - Bovine Leukocyte Adhesion Deficiency, Citrullinaemia, Deficiency of Uridine Monophosphate Synthase. Factor XI deficiency syndrome; Genetic testing for disorders.	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Assisted Breeding & Animal Biotechnology**	
2.1	Evaluation and characterization of animal genetic resources–breed characterization, genetic resource diversity; Markers–morphological, cytological, biochemical and molecular markers.	3
2.2	Ex-situ and in-situ conservation of animal genetic resources–cryoconservation-methods	2
2.3	Reproductive endocrinology –endocrine tissues, endocrine hormones, estrous cycle; Artificial insemination,ICSI, Oocytes, embryo transfer, ONBS, MOET technology in animal breeding	3
2.4	Synchronization, superovulation and IVM/IVF embryo production, *in vitro* embryo production and micromanipulation of embryos; Sperm and embryo sexing.	3
2.5	Transgenesis-methods of production of transgenic animals; agriculture applications, biomedical applications-molecular farming &pharmanimals	3
2.6	Animal cloning-somatic cell nuclear transfer, artificial cloning of livestock and transgenic animal production	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Animal Cell Culture Technology**	
3.1	Equipment and materials for animal cell culture technology; culture medium –natural and synthetic media, sera, balanced salt solutions	2
3.2	Development of cell lines–primary culture, established cell cultures; characteristics of cell in culture–contact inhibition, anchorage dependence, cell-cell communication, cell senescence	3
3.3	Characterization of cell lines: morphology, chromosome analysis, DNA content, enzyme activity, antigenic markers, differentiation	3
3.4	Cell transformation: DNA transfer–calcium phosphate, lipofection, electroporation, nucleofection and viral vectors	3
3.5	Scaling up of cultures at large scale production-cell culture fermentors; Application of cell cultures-mass production of biologically important substances, expression of recombinant proteins in mammalian cell lines	3
3.6	Stem cells–different types, embyronic and adult stem cells, iPS cells, gene targeting to stem cells	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Mouse in Biomedical Research**	
4.1	Mouse development potency,commitment,specification,induction,competence,determination and differentiation, morphogenetic gradients, cell fate and cell ineages,stemcells,productionofgametes,fertilization,zygoteformation	3
4.2	Embryonic development cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in mouse. Allopheny	2
4.3	Mouse as disease model-standard laboratory strains, mating & breeding, transgenic mouse, knock-out and knock-in strategies, inducible gene expression strategies, TALEN and CRISPR-cas9 technology	3
4.4	Cancer models - carcinogen injection models, bone marrow transplantation models, xenograft models, retrovirus, lentivirus and adenovirus-based tumor models ,transgenic tumor models, double transgenic models	3
4.5	Neurodegenerative disease models: Alzheimer's (Infusion model, Tau-knockout and APP-over expressing mouse), Parkinson's (Neurotoxin administration model), Huntington's (HTT transgenic mouse)	2
4.6	Infectious disease models: Mouse models of Streptococcus and HIV, Humanized mouse and its applications	3

PRACTICALS

G353P (1B): ANIMAL GENETICS & MOUSE MODELS

S.No.	Topic to be covered	No. of hours
1	Laboratory animal species maintenance & specific utility-mice and rat	4
2	Mating methods	4
3	Genetic control and monitoring-record keeping	4
4	Management & use of laboratory animals-ethics and legislation	4
5	Strains and inbred lines-nomenclature.	4
6	Animal facility maintenance, mouse handling and ear-marking	4
7	Collection of blood, Intra-peritoneal and tail-vein injection.	4
8	Karyotype of farm animal species	4

REFERENCE BOOKS

1. Animal Genetics and Breeding (2015) by Arun&Tomar, Daya Publishing House
2. Animal Biotechnology (2005) edited by Srivastava, Singh &Yadav. Oxford & IBH Publishing Co. Pvt. Ltd
3. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications(2015) seventh edition by Ian Freshney,Wiley Blackwell
4. Genetic Engineering in Livestock: New Applications and Interdisciplinary perspectives (2009) edited by Margret Engelhard, Kristin Hagen., Springer
5. The Mouse in Biomedical Research (2007) 2ndedition, vol. III Normative Biology, Husbandry and Models. Editors Fox et al., Elsevier

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER- IV: ELECTIVE 2(A)
G304T: PLANT GENOMICS & BIOTECHNOLOGY

1. **Course Objectives (C.Obj)**
   a. To understand the plant genome organization , structural and functional genomics
   b. To comprehend and manipulate the plant secondary metabolism
   c. To culture and manipulate the plant cells
   d. To genetically manipulate the plant system

2. **Course Outcomes (C.O)**
   a. Student is aware with the latest sequencing and bioinformatics analysis tools andis able to apply in the structural and functional genomics of plants
   b. Acquires knowledge on basic characteristics of plant secondary metabolism andskills for manipulation through metabolic engineering
   c. Student is exposed to different applications of plant cell cultures in medicine andindustry
   d. Able to generate transgenics for different applications

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Plant Genomics**	
1.1	Plant nuclear genome- genome organization in plant nucleus, Plant organellar genomes - plastid and mitochondrial genomes	3
1.2	Plant epigenome –epigenomic reprogramming in gametogenesis and seed development in plants, endosperm imprinting, histone modifications in response to light, natural epigenome variation in plants, heterosis	3
1.3	Plant genome sequencing strategies- high-throughput sequencing technologies, single molecule and real time sequencing, assembly & alignment programs, genome browsers	3
1.4	Plant proteomics- high throughput approaches–mass spectrometry based proteomics	3
1.5	Plant metabolomics- analytical platforms–GC-MS, NMR, MALDI	2
1.6	Plant genome editing and genome engineering applications- ZFN, TALENs, CRISPR-Cas9 and ODM	2

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Plant Secondary Metabolism & Metabolic Engineering**	
2.1	Secondary metabolites-transport storage and turnover, ecological functions & uses of secondary metabolites in biotechnology	2
2.2	Terpenoids- synthesis of IPP, phenyl transferase and terpene synthase reactions, modification of terpenoid skeletons	3
2.3	Alkaloid biosynthesis– nicotine and tropane alkaloids, benzyl isoquinoline alkaloids, moneterpene indole alklaoids	3
2.4	Phenolic compounds – phenyl propanoid, phenyl propanoid-acetate pathways, Lignin& flavonoid biosynthesis	3
2.5	Coumarins – classification, simple coumarins and Furanocoumarins, stilbenes, styrylpyrones and arylpyrones	2
2.6	Plant metabolic engineering-Approaches to metabolic engineering-biotechnological application of alkaloid biosynthesis, phenolics metabolic engineering, terpenoids metabolic engineering.	3

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Plant Cell Biotechnology**	
3.1	Introduction to plant cell culture – different plant tissue culture media, role of plant growth regulators in tissue culture	2
3.2	Plant cell culture technique- callus and cell suspension cultures; applications of plant cell cultures	2
3.3	Somatic embryogenesis – induction of somatic embryos, production and applications of synthetic seeds	3
3.4	Cryo-preservation- theoretical basis, methods and applications of cryo-preservation.	2
3.5	Plant secondary metabolites produced by cell cultures, strategies to improve secondary metabolite production in plant cell cultures -cell line selection, medium optimizations, permeabilization, elicitation, cell immobilization, biotransformation	4
3.6	Mass cultivation of plant cell and organ culture- modes of bioreactor operations, different types of bioreactors, hybrid reactors and disposable bioreactors	3

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Transgenic Plants**	
4.1	Co-integrated vectors, binary vectors, novel and specialized vectors for transformation	2
4.2	Selectable markers (positive & negative selection), novel selection methods and restriction enzymes to control T-DNA integration; marker free transgenic technology; analysis of transgenic plants	3
4.3	Chloroplast transformation – advantages of chloroplast transformation; transplastomic plants -applications	2
4.4	Molecular farming- advantages of transgenic plants as bioreactors, expression systems, sub-cellular targeting, plant expression hosts, downstream processing & purification	3
4.5	Molecular farming for biopharmaceuticals – (plantibodies, plantigens, therapeutic proteins & edible vaccines)	3
4.6	Molecular farming for industrial products (industrial enzymes, lysozyme, biopolymers, biofuel, paper manufacturing)	3

PRACTICALS

G354P (2A): PLANT GENOMICS AND BIOTECHNOLOGY

S.No.	Topic to be covered	No. of hours
1	Genome browsers	4
2	TLC for screening of plant extracts	4
3	Preparation of different types of standard tissue culture media (MS and White's medium)	4
4	Induction of callus and initiation of cell suspension cultures	4
5	Production of synthetic seeds	4
6	Plant cell immobilization and biotransformation for secondary metabolite production	4
7	Determining copy number in transgenic plants	4
8	Gateway cloning	4

REFERENCE BOOKS

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

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER- IV: ELECTIVE 2(B)
G304T: PLANT NUTRACEUTICALS AND NUTRIGENOMICS

1. **Course Objectives (C.Obj)**
   a. To comprehend the classification, biosynthesis of principal secondary metabolitesand production of phytochemicals
   b. To identify the role of nutrigenetics and nutrigenomics
   c. To know the tools used in nutrigenomics
   d. To state the role of phytochemicals and nutraceuticals in health

2. **Course Outcomes (C.O)**
   a. Able to apply and produce phytochemicals through plant cell biotechnology
   b. Student be able to comprehend and apply the role of polymorphism, biomarkersand microRNAs in nutrigenomics
   c. Gains knowledge & skills in using advanced tools and techniques innutrigenomic analysis
   d. Enables to know and develop functional foods and biofortification procedures

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Phytochemicals: classification, biosynthesis and production**	
1.1	Secondary metabolites and phytochemicals –function of secondary products in plants, health benefits of phytochemicals	2
1.2	Phytochemical classes and chemical properties	3
1.3	Biosynthetic pathways of secondary product classes –Terpenoid and shikimate pathways, isoprenoid pathway, polyketide pathway;	3
1.4	*In vitro* techniques for the cultivation of nutraceutical plants, factors determining accumulation of secondary metabolites, strategies to improve metabolite production, biological elicitors of plant secondary metabolites (mode of action and use in production of nutraceutics)	3
1.5	Phytochemicals in plant cell bioreactors –plant bioreactors; commercial production of plant secondary metabolites	2
1.6	Hairy root culture for secondary metabolites production –A. rhizogenes transformed medicinal plants for metabolite production, bioreactors and hairy root culture	3

Unit Number	Topics to be covered	No. of lectures
UNIT 2	**Nutrigenetics and Nutrigenomics**	
2.1	Nutritional genetics *vs* nutritional genomics	2
2.2	Nutrients modulating genome expression –nutrient as signal molecule, mechanisms of nutrient perception	3
2.3	Nutrigenetic diseases and Nutrigenomic diseases –PKU, Obesity, CVD, Cancer, Inflammation, Diabetes, Osteoporosis	3
2.4	Variation in human populations -gene polymorphism, SNP, nutritional implications; personalized nutrition	3
2.5	Biomarkers –biomarkers of biological effect -enzyme function, oxidative stress, immune function, bone health, cell turnover; biomarkers for genetic susceptibility	3
2.6	MicroRNAs as dietary bioactive compounds –characteristics, biogenesis and functions	2

Unit Number	Topics to be covered	No. of lectures
UNIT 3	**Advanced Tools in Nutrigenomics**	
3.1	Genetic selection- insertional inactivation and alpha complementation	2
3.2	Use of animal and cell models in nutrition and food research: *in vitro* models applicable in nutrigenomic studies, use of animal models– advantages and limitations	2
3.3	Transcriptomics- mRNA profiling, cDNA-AFLP, DNA microarrays, SAGE, MIAME/Nut; using transcriptomics to explain mechanism behind differences in response to diet	2
3.4	Proteomics-2D-DIGE, ELISA, protein microarray, MALDI-TOF, PSI (Proteomics Standard Initiative) –role of proteomics in nutrigenetics and nutrigenomics	2
3.5	Metabolomics-analytical tools–LC resolved and GC resolved mass spectrometry, NMR spectroscopy, global *vs* targeted metabolic profiling-applications to nutrition, metabolomics.	3
3.6	High throughput genomic screening –control of gene expression, methods of target validation (cell line testing, animal models) screening model	3
3.7	Bioinformatics–screening for bioactive nutrients and compounds, genome annotation, gene prediction, DNA motifs	2

Unit Number	Topics to be covered	No. of lectures
UNIT 4	**Phytochemicals and Nutraceuticals in Health & Disease**	
4.1	Nutraceuticals - isoprenoid derivatives, phenolic compounds, carbohydrate derivatives, amino acid derivatives and minerals (Ca, Zn, Cu, K, Se)	2
4.2	Nutraceuticals and antioxidant function-oxidative stress and ROS, antioxidants (amino acids, peptides and proteins), antioxidant defense systems, phytochemicals	3
4.3	Phytochemicals and cancer-models of carcinogenesis, cancer risk - nutrients and phytochemicals; impact on cancer metastasis suppressor genes, phytoestrogen	2
4.4	Phytochemicals in immune function-carotenoids and flavonoid	2
4.5	Plant lipids in health and disease; plant tochopherols/tocotrienols and health	2
4.6	Functional foods in prevention of human health disorders-cancer prevention	2
4.7	Biofortification with phytochemicals; probiotics-prebiotics, synbiotics	3

PRACTICALS

G354P (2B): PLANT NUTRACEUTICALS AND NUTRIGENOMICS

S.No	Topic to be covered	No. of hours
1	Extraction of phytochemicals	4
2	Analysis of antioxidant capacity of phytochemicals	4
3	Chromatographic separation and detection of phytochemicals	4
4	*In vitro* cultivation technique of nutraceutical plants	4
5	Induction of callus and initiation of cell suspension cultures	4
6	Hairy root transformation for production of secondary metabolites	4
7	Gene polymorphism-SNPs and gene expression analyses	4
8	Gene prediction & DNA motifs	4

REFERENCE BOOKS

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

M Sc GENETICS II YEAR
SEMESTER IV
THEORY PAPER-I
G 401 T: BIOINFORMATICS

1. **Course objectives**
   a. Understanding the complexities associated with the biological information
   b. Understanding the basics of application of computers and information technology principles in biology
   c. Understanding the principles behind the analysis of biological information
   d. Understanding the application of bioinformatics in specific areas of Biology

2. **Course Outcome**
   a. Can access and use all bioinformatics resources
   b. Will have the knowledge on the principles behind various Bioinformatics analysis
   c. Perform various basic computational analysis of biological information
   d. Will have the basic knowledge on computational biology so that one can easily learn complex bioinformatics analysis methods

3. **Course Plan/Schedule**

Unit Number	Topic to be covered	Number of lectures
UNIT-1	**FOUNDATION OF BIOINFORMATICS**	
1.1	Bioinformatics- a historical perspective	2
1.2	Bioinformatics data – Nucleic acid sequence, protein sequence, protein structure, genome variation data, gene expression data, proteomic data, metabolic pathways and networks	5
1.3	Bioinformatics Databases- What are databases, why databases, types of databases, file formats (Examples: Genbank- DNA sequence, Uniprot- protein sequence, PDB-Structure, CATH, SCOP-protein classification, Unigene-transcripts, KEGG-metabolic pathway, dbSNP-variation, RAP-DB-genome-specific)	3
1.4	Database Search methods: key word, accession number and sequence based searches, search engines (Entrez and SRS)	2
1.5	Bioinformatics tools and resources- role of internet, free online tools, downloadable free tools, software packages	2
1.6	Bioinformatics web portals (NCBI, EBI & Xpasy)	2

UNIT-2	**COMPARISON METHODS IN BIOINFORMATICS**	
2.1	Basic sequence alignment: match, mismatch, gaps, scoring an alignment (match-mismatch scores, gap penalties (linear and affine gap penalties), sequence relationships (sequence identity, similarity, homology, orthologs, paralogs & xenologs)	2
2.2	DNA vs Protein Sequence alignment: permissible replacements, similarity score, Scoring matrices (PAM & BLOSUM)	2
2.3	Pairwise alignment: Dot-matrix comparison of sequences, Dynamic programming based Pairwise alignment algorithms (Global– Needleman-Wunch algorithm, Local– Smith-Waterman algorithm)	4
2.4	Pairwise alignment based database searching-rigorous algorithms for database searching (Needleman- Wunch, Smith- Waterman), Heuristic algorithms for database searching: FASTA algorithm and BLAST algorithm	4
2.5	Multiple-sequence alignment: Significance of MSA, Progressive and Iterative alignment based algorithms for multiple sequence alignment	2
2.6	Multiple sequence alignment based database searching: Consensus sequence, nucleotide distribution matrix, sequence profile and Position specific scoring matrix, Profile BLAST	2
UNIT-3	**BIOINFORMATICS APPLICATIONS IN GENOMICS**	
3.1	Bioinformatics for genome sequencing, first and next generation methods of genome sequencing; De-novo and reference based genome assembly (reads, contigs, scaffolds)	3
3.2	Transcript-profiling: Expression microarrays (gene array, oligo array); Transcriptome sequencing and RNA-seq analysis.	3
3.3	Genome annotation: finding repeats, gene finding in prokaryotes and eukaryotes.	3
3.4	Genome maps and markers: genome wide identification of molecular markers (SSR, STS & SNP markers), linkage vs physical maps. visualizing genome maps and annotation information (genome browsers)	2
3.5	Genome variation studies: whole genome duplications and its implications, segmental duplication (copy number variation) its implications, single nucleotide variation identification and its implications	3
3.6	Medical applications of Bioinformatics: Bioinformatics for understanding diseases, identification of disease genes and disease diagnostics; overview of drug discovery & pharmacogenomics	2

UNIT-4	APPLICATIONS OF BIOINFORMATICS IN PROTEOMICS AND METABOLOMICS	
4.1	Protein profiling (2D gels, protein fingerprinting & identification)	3
4.2	Protein classification: Scop and CATH schemes of classification (motifs, domains, folds, class, architecture, family & super family)	2
4.3	Protein structure-1: Structure visualization, prediction of conserved regions (motifs & domains), secondary structure prediction	4
4.4	Protein structure-2: Tertiary structure prediction (Homology modelling)	3
4.5	Phylogenetic analysis (Distance matrix, UPGMA based tree construction)	2
4.6	Metabolic pathways, Metabolic networks, Computational metabolic reconstruction	2

PRACTICALS

G 451 P: BIOINFORMATICS

S No	Topic to be covered
1.	Bioedit as the sequence handling tool
2.	Understanding DNA/Protein coding systems
3.	Understanding file formats (FASTA, FastQ, BAM
4.	Exploring Sequence databases (Genbank and Uniprot)
5.	Exploring Structure database (PDB and MMDB)
6.	Key word & accession number based database search & downloading bioinformatics data **a.** Downloading DNA sequence data (Genbank/DDBJ/ENA) **b**. Downloading protein sequence data (Uniprot) **c.** Downloading protein structure data (PDB/MMDB) and visualization **d**. Downloading bioinformatics data from FTP servers (NCBI)
7.	Pairwise (global and local) alignment of DNA sequences
8.	Pairwise (global and local) alignment of protein sequences
9.	Multiple sequence alignment of DNA and protein sequences using Clustal-W
10.	Database searching with heuristic (FASTA and BLAST) and rigorous algorithms (Needleman and Wunch and Smith and Waterman algorithms)
11.	Exploring genome specific databases (RAP-DB)
12.	Exploring gene databases (Entrez gene, Gene cards)
13.	Prediction of genes in prokaryotic and eukaryotic genomes
14.	Prediction of SSRs in DNA sequence (SSRit)
15.	Prediction of secondary structures of proteins online
16.	Homology modelling online.
17.	RNA secondary structure prediction (Mfold)

REFERENCE BOOKS

1. Introduction to Bioinformatics By Aurther M lesk
2. Developing Bioinformatics Computer Skills By: Cynthia Gibas, Per Jambeck
3. Chemoinformatics: A Textbook by Johann Gasteiger
4. Bioinformatics second edition By David M mount
5. Essential Bioinformatics By Jin Xiong
6. Bioinformatics Computing By Bryan Bergeron

MSc GENETICS II YEAR
SEMESTER IV
THEORYPAPER-II
G402T- APPLIED MICROBIAL GENETICS

1 Course Objectives (C.Obj)

a. To become familiar with the classification, life cycle and genetics of microbial flora - bacteria, virus, fungi, protozoan and algae.
b. To acquaint plant-microbial interactions and their applications in plant stress, cleaning environment, control of pests and weeds, bio-fertilizers and metagenomics
c. To become aware of microbial genetics for strain improvement, and applications of microbial genetics in enzyme technology, bio-fuel production and degradation of pollutants.
d. To comprehend microbial pathogenesis, emerging and re-emerging infectious diseases and applications of microbial genetics in diagnosis, vaccine and biologicals development

2 Course Outcomes (C.O)

a. The student is able to utilize microbial classification and life cycle advances for genetic applications
b. the student acquaints with skills necessary in utilization of plant microbe interactions for agriculture.
c. Gain skills in microbe strain development and utilizes for industrial and environmental purpose
d. The student is able understand microbial pathogenesis and utilizes skills in the areas of microbial diagnosis, vaccine and biological development

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT-1	**Biology & Genetics of Microorganisms**	
1.1	Bacteria - classification, structure & function of bacterial cells, general life cycle, bacterial genetics (plasmids, conjugation, transduction, transformation)	4
1.2	Virus - classification, virion structure, general viral life cycle (phage virus reproduction– lytic & lysogenic cycle), viral genetics (mutations, recombination, reassortment, complementation, phenotypic mixing)	3
1.3	Fungi - classification; structure; fungal life cycles (*Aspergillus*) – types; fungal genetics (mating systems, outcrossing, non-out crossing, parasexual cycle)	3
1.4	Protozoan - structure; classification; life cycle (*Trypanosoma*); protozoan genetics (genetic exchange in *Trypanosoma brucei*, *Leishmania*)	3
1.5	Algae - structure, life cycle (*Chlamydomonas reinhardtii*), tetrad analysis, zygote plating	3

UNIT-2	**Agricultural applications**	
2.1	Beneficial plant-microbe interactions (genetics and molecular biology): plant- fungal interactions (mycorrhizal symbiosis) and plant-bacterial interactions (PGPB)	4
2.2	Protection from plant stress & cleaning environment: Microbial associations for plant stress tolerance, rhizoremediation	3
2.3	Microbial control of pests and weeds: microbial biopesticides, bioinsecticides, bioherbicides	3
2.4	Microbe assisted crop improvement- biofertilizers, metal tolerant bioinoculants, biofilms, phosphate solubilizing microbes, AMF, siderophores	3
2.5	Metagenomics of plant - microorganism interactions: methods & applications	3

UNIT-3	**Industrial and Environmental applications**	
3.1	Genetic improvement of strains for biotechnological purposes- Strategies for strain improvement, mutation & selection, conventional breeding, protoplast fusion, *in vitro* recombinant DNA technology	4
3.2	Applications of microbial genetics in enzyme technology- improving efficiency of enzyme production, generation of novel enzymes- strategies, site-directed mutagenesis, directed evolution, antibody catalysis, computational redesign, de novo methods	4
3.3	Microbial biofuel production- bioethanol, biodiesel, biohydrogen	3
3.4	Microbial detection of pollutants, microbial degradation of organic compounds that generate environmental problems	3
3.5	Microbial bioremediation- engineering bacteria for bioremediation, bioaugmentation	2

UNIT-4	**Medical applications**	
4.1	Genetic & molecular basis of pathogenesis: bacterial (*Vibrio cholera*), viral (*HIV*), fungal (*Candida*), protozoan (malaria), prions (BSE)	4
4.2	Emerging & re-emerging infectious diseases/pathogens- epidemiology, pathogens- acute respiratory diseases, acute diarrheal illnesses	3
4.3	Molecular diagnosis of pathogens (HIV, Hepatitis, pathogens in lower respiratory tract infections, gastrointestinal pathogens)- methods and applications	3
4.4	Recombinant vaccine strategies- recombinant vaccines using bacterial or viral vectors, novel vaccines - mini cells, vaccinia virus recombinants, synthetic peptide vaccines, subunit vaccines (recombinant subunit vaccine- Hepatitis B vaccine, ViCPS vaccine), DNA vaccines, reverse vaccinology	3
4.5	Pharmaceuticals & Biologicals: expression systems, *in vitro* techniques to modify therapeutic proteins, recombinant human gene products expressed in bacteria or fungi, secondary metabolites as source of drugs	3

PRACTICALS

G452P: APPLIED MICROBIAL GENETICS

SNo.	Topics to be covered
1.	Preparation of media
2.	Enumeration of microbes
3.	Staining techniques for microbe identification
4.	Examination of fungal & protozoan types/Spectrometric analysis Of bioremediation
5.	Induction of mutations in bacteria / Replica plating for isolation of auxotrophic mutants
6.	Identification of different genera of VA mychorrhizal fungi / Biofilm formation in glass tubes / Culturing nitrogen fixing bacteria from root nodules of leguminous plants
7.	Lyophilization / Plasmid profile analysis
8.	PCR detection of microbial pathogen /Gene expression analysis using reporter gene assay

REFERENCE BOOKS

1. Microbial genetics applied to biotechnology by Venetia A. Saunders, Springer
2. Primary Care: A Collaborative Practice by Terry Mahan Buttaro, Elsevier
3. Microbiology: A Clinical Approach, second edition (2015), Anthony Strelakauskas,Angela Edwards, Beatrix Fahnert, Garland Science
4. Principles of Plant-Microbe Interactions–Microbes for Sustainable Agriculture (2015)Editor Ben Lugtenberg, Springer
5. Medical Microbiology Seventh Edition (2013) Murray, Rosenthal, Pfaller; Elsevier,Saunders
6. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) byBernard R. Glick, Jack J. Pasternak, Cheryl L. Pattern. ASM Press
7. Molecular Diagnostics of Infectious Diseases 3rd Edition Harald H. Kessler (Ed.) Published by Walter de Gruyter GmbH & Co KG

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

1. Course Objectives (C.Obj)

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

2. Course Outcomes (C.O)

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

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Cell differentiation, tissue development and cell culture**	
1.1	Basics of growth and differentiation in animal cell- cell structure and function of organelles, cell division and cell cycle, cell determination & differentiation, cell death- apoptosis, tissue organization, tissue components, tissue types	3
1.2	Dynamic states of tissues, homeostasis in highly prolific tissues & tissue repair and regeneration, matrix molecules & ligands, cell- ECM interactions, malfunctions in ECM signaling, cell junctions in tissues, angiogenesis	2
1.3	Measurement of cell characteristics - cell number and viability, cell-fate processes (cell proliferation, differentiation, embryonic cellular movement and programmed cell death), cytoskeleton and cell motility (microtubules, intermediate filaments, microfilament, cilia and flagella), cell function	3
1.4	Response to mechanical stimuli, inductive phenomena (instructive and permissive), embryonic morphogenesis & regeneration	3
1.5	Establishment of cell culture - cells expansion and characterization-cell signaling molecules, growth factors, hormone and growth factor signaling; cell transfer and storage- cell attachment, differential cell adhesion, receptor ligand binding and cell surface markers	3
1.6	Animal cell culture (culture media and role of serum in cell culture, culture environment & cell separation, maintenance of cells *in vitro* and subculturing, primary cells vs. cell lines), cryopreservation and reconstitution of cell lines	2

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

UNIT 4	**Tissue engineering of organs, its regulatory and ethical issues**	
4.1	Musculoskeletal tissue engineering: Bone tissue engineering, composition, & functions; Biomaterials, Cell sources & growth factors for Bone tissue engineering, Cartilage tissue engineering, composition, types of cartilage & functions; Biomaterials, Cell sources & growth factors for cartilage tissue engineering	3
4.2	Soft tissue engineering- skin: Structure and functions of skin, Tissue-engineered therapy with stem cells, bioactives, and biomaterials. Bioengineered skin (Apligraf & Dermagraft)	2
4.3	Hepatic tissue engineering-Liver architecture and function; Biomaterials, Cell sources &growth factors for liver tissue engineering	3
4.4	Regeneration of cornea-Corneal anatomy and functions; therapeutic approaches for different corneal cell types: epithelial tissue engineering, stromal tissue engineering and endothelial tissue engineering	3
4.5	Tissue engineering- Current challenges; Future directions: Smart biomaterials, Cell sources, Whole organ engineering, advances in Biofabrication technologies, Tissue neovascularization etc.	2
4.6	Regulatory issues: Regulatory background-FDA, Tissue-engineered and regenerative medicine products-regulatory challenges, regulation of HCT/Ps. Responsibilities of sponsors and investigators; Ethical issues pertaining to genetic privacy, ownership, religious faiths, therapeutic vs cosmetic use, nature of identity. Policies etc	3

PRACTICALS
G 453 P (3A): CELL AND TISSUE ENGINEERING

SNo.	Topic to be covered	No. of hours
1.	Tissue culture basics-Sterilization of Tissue culture components, Preparation of tissue culture media RPM1-1640/MEM/DMEM, Filtration of tissue culture media	4
2.	Tissue culture/ Cell culture maintenance- Maintenance of tissue culture, Sub culturing (Trypsinization, Passaging & Seeding)	4
3.	Cell counting - Counting cells on hemocytometer, Trypan blue exclusion test	4
4.	Cell Viability assay- MTT assay to determine the metabolic activity of cell	4
5.	Cell invasion and migration assay- Cell culture wound closure assay	4
6.	Colony formation assay	4
7.	Spheroid formation assay	4

REFERENCE BOOKS

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

M Sc GENETICS II YEAR
SEMESTER- IV
THEORY PAPER-III (ELECTIVE-3)
G403T (3B): GENETIC TOXICOLOGY

1. **Course Objectives (C.Obj)**
   - **a.** To know the mechanisms of genetic toxicology and its application for human and environment monitoring
   - **b.** To acclimatize to evaluation of genotoxicity utilizing mammalian systems
   - **c.** To familiarize to the methods of evaluation of genotoxicity utilizing non mammalian cell based and novel assays
   - **d.** To comprehend the methods of evaluation of genotoxicity utilizing plant systems and omics approaches

2. **Course Outcomes(C.O)**
   - **a.** The student is able to utilize mechanisms of mutagenesis and carcinogenesis for environmental and human health monitoring
   - **b.** The student acquaints with skills necessary for conducting genotoxicity assays using mammalian systems
   - **c.** The student gain skills in handling non-mammalian systems and novel assays for evaluation of genotoxicity
   - **d.** The student is able to evaluate genotoxicity with plant systems and omics tools

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT-1	**Genetic toxicology**	
1.1.	History of genetic toxicology- role of genetic toxicology in health effect testing	2
1.2.	Cell cycle and chromosome mechanics in somatic and germ cells – somatic vs germ cells, chromosome, mitotic cell cycle, meiosis & chromosome mechanics	3
1.3.	DNA damage and repair- post-replication repair, excision repair, base replacement, deletions and insertions; Mutagenesis- single nucleotide point mutations, intercalating frame shift mutagens, cross linking mutagens, clastogenic mutagens	4
1.4.	Carcinogenesis- physical, chemical and biological agents; mechanisms of carcinogenesis, oncogenes or tumor suppressor genes, chromosomal abnormalities leading to cancer, epigenetic carcinogens	3
1.5.	Consequence of genotoxic effects in humans and other mammals- gene pool consequences, relationship of genotoxic effect to other toxicologic phenomena; Applications of genetic toxicology- human & environment monitoring	4

UNIT-2	**Mammalian based evaluation of genotoxicity**	
2.1.	*In vitro* gene mutation – bacterial reverse mutation assay (Ames test), mammalian cell *Hprt* mutation; *In vivo* gene mutation - Rodent lymphocyte *Hprt* mutation assay, mouse spot test, mouse specific locus test, transgenic rodent gene mutation assay (somatic & germ cells)	3
2.2.	*In vitro* gene mutation & chromosome mutation – mouse lymphoma forward mutation assay (L5178Y/*Tk*+/-), *Tk* gene mutation assay	2
2.3.	*In vitro* clastogenicity – mammalian chromosomal aberration assay; *In vitro* clastogenicity and aneugenicity – rodent micronucleus assay (bone marrow & peripheral blood), micronucleus assay (human lymphocytes); *In vivo* clastogenicity (germ cell) – rodent dominant lethal test, mouse heritable translocation assay	4
2.4.	Chromosome aberration (germ cells)– mammalian spermatogonial chromosome aberration test, *in vivo* chromosomal aberration tests-rodent bone marrow chromosomal effects	3
2.5.	*In vitro*/*In vivo* DNA strand break– comet assay, alkaline elution assay; *In vitro*/*In vivo* DNA repair – UDS assay, UDS assay in hepatocytes	2
2.6.	*In vitro*/*In vivo* DNA damage – Sister chromatid exchange in mammalian cells; *In vitro* DNA adducts – DNA adduct analysis	2

UNIT-3	**Non-mammalian, Cell and Novel based evaluation of genetic toxicity**	
3.1.	Gene mutation in mammalian cells in culture – CHO *HGPRT* gene mutation assay, V79 *HGPRT* gene mutation assay, AS52/Xprt mutation assay in Chinese hamster cells	4
3.2.	Gene mutation in *Saccharomyces cerevisiae*; *in vitro* cytogenetic assay – mitotic recombination in *Saccharomyces cerevisiae*	2
3.3.	*In vivo* cytogenetic assay – drosophila sex-linked recessive lethal test; Genome mutation assays –specific locus test in *Neurospora*	3
3.4.	Mammalian cell transformation (*in vitro* carcinogenesis)– BALB/c-3T3 cells, C3H10T1/2 cells; Novel assays– gamma-H2AX, GADD45a-GFP Green Screen; Biomarkers– application of biomarkers for human risk assessment	4
3.5.	Nongenotoxic carcinogen mechanisms – kidney cancer in male rats & alpha-2 microglobulin nephropathy, mouse liver tumors, peroxisome proliferation, dioxin & aryl hydrocarbon receptor	3

UNIT-4	Evaluation of genetic toxicity with plant systems and 'omics'	
4.1	Carcinogens in plants– mycotic toxins, mushroom toxins, streptomyces toxins; Genotoxicity & carcinogenicity of herbal products – volatile alkenyl benzenes, anthraquinones	4
4.2	Genotoxic agents in agro-ecosystem– mutagenicity and carcinogenicity of pesticides	2
4.3	Plant dependent mutation assays - higher plant genetic systems for screening & monitoring mutagens	3
4.4	Transgenic plants for environmental pollution genotoxicity – transgenic systems, marker genes used for mutation assay	3
4.5	*In silico* approaches– QASR computational toxicology, *Ab initio* molecular models for genotoxicity	2
4.6	Toxico genomics– high throughput screening of genotoxicity-ToxTracker assay	2

PRACTICALS

G453P (3B): GENETIC TOXICOLOGY

S No	Topics to be covered
1.	Comet assay
2.	Bacterial reverse mutation assay
3.	*In vitro* micronucleus test
4.	Chromosomal aberration test
5.	Sister chromatid exchange assay
6.	SLRL
7.	*In silico* genetic toxicology analysis
8.	Allium chromosome aberration test

REFERENCEBOOKS

1. Principles of Genetic Toxicology (2013) by D. Brusick Second Edition, Springer
2. Genetic Toxicology Testing -A Laboratory Manual edited (2016) by Ray Proudlock Elsevier Academic Press
3. Genetic Toxicology: An Agricultural Perspective edited by Raymond F. Fleck, Plenum Press
4. Transgenic plants as sensors of environmental pollution genotoxicity (2008) Kovachuk and Kovalchuk.Sensors 8(3), 1539-1558
5. Toxicology of Herbal Products edited by OlaviPelkonen, Pierre Duez,PiaMaaritVuorela,HeikkiVuorela

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SEMESTER- IV

G 404 T: PROJECT WORK

G 454 P: PROJECT THESIS PRESENTATION