MSC GENETICS II YEAR
SEMESTER - III

S N	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**

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)

a. Understanding the fundamentals of cloning processes and components involved
b. Comprehension of various molecular biology techniques and their applications
c. Acquaintance with recombinant DNA and DNA sequencing techniques
d. Knowledge regarding the use of rDNA techniques in modern biology, medicine and 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 7th Edition; 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 University Press
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.

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 about autoimmune 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 culture	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 by HGP
   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 & Bartlett publishers, 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, quantitative genetics and testing of disorders in different animals of animal husbandry
b. To familiarize with the role of markers, genetic resources, assisted breeding and transgenic 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 and breeding

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,determinationanddifferentiation,morphogeneticgradients,cellfateand cell ineages,stemcells,productionofgametes,fertilization,zygoteformation	3
4.2	Embryonic development cleavage,blastulaformation,embryonicfields,gastrulationandformation ofgermlayersinmouse.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-overexpressing 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 and is able to apply in the structural and functional genomics of plants
b. Acquires knowledge on basic characteristics of plant secondary metabolism and skills for manipulation through metabolic engineering
c. Student is exposed to different applications of plant cell cultures in medicine and industry
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, phenyltransferase 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 Arie Altman, 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, Wilhelm Gruissem, 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 metabolites and 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, biomarkers and microRNAs in nutrigenomics
c. Gains knowledge & skills in using advanced tools and techniques in nutrigenomic 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, CAB International
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 by GopinadhanPaliyath, MaricaBakovic, KalidasShetty, Wiley-Blackwell
5. Nutrition and Immunology: Principles and Practice edited by M. Eric Gershwin, J. Bruce German, Carl L. Keen, Springer.