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

SEMESTER – I

S N	Syllabus Ref No	Papers	Credits	Teaching hours/ week	Marks		
					Internal assessment	Semester exam	Total
THEORY							
1.	G 101 T	Principles of Inheritance	4	4	20	80	100
2.	G 102 T	Cell Biology & Cytogenetics	4	4	20	80	100
3.	G 103 T	Fundamentals of Biochemistry	4	4	20	80	100
4.	G 104 T	Biostatistics and Population Genetics	4	4	20	80	100
PRACTICALS							
1.	G 151 P	Principles of Inheritance	2	4		50	50
2.	G 152 P	Cell Biology & Cytogenetics	2	4		50	50
3.	G 153 P	Fundamentals of Biochemistry	2	4		50	50
4.	G 154 P	Biostatistics and Population Genetics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER – II

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

SEMESTER - III

SN	Syllabus Ref. No	Papers	Credits	Teaching hours/ week	Marks		
					Internal assessment	Semester exam	Total
THEORY							
1.	G 301 T	Genetic Engineering	4	4	20	80	100
2.	G 302 T	Immunogenetics	4	4	20	80	100
3.	G 303 T	**ELECTIVE 1**: **A.** Human Genomics & Medical Genetics **B.** Animal Genetics & Mouse Models	4	4	20	80	100
4.	G 304 T	**ELECTIVE 2**: **A.** Plant Genomics & Biotechnology **B.** Plant Nutraceuticals & Nutrigenomics	4	4	20	80	100
PRACTICALS							
1.	G 351 P	Genetic Engineering	2	4		50	50
2.	G 352 P	Immunogenetics	2	4		50	50
3.	G 353 P	**A.** Human Genomics & Medical Genetics **B.** Animal Genetics & Mouse Models	2	4		50	50
4.	G 354 P	**A.** Plant Genomics & Biotechnology **B.** Plant Nutraceuticals & Nutrigenomics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER - IV

SN	Syllabus Ref. No	Papers	Credits	Teaching hours/ week	Marks		
					Internal assessment	Semester exam	Total
	THEORY						
1.	G 401 T	Bioinformatics	4	4	20	80	100
2.	G 402 T	Applied Microbial Genetics	4	4	20	80	100
3.	G 403 T	**ELECTIVE 3:** **A.** Cell & Tissue Engineering **B.** Genetic Toxicology	4	4	20	80	100
4.	G 404 T	Project Work	4	4	20	80	100
PRACTICALS							
1.	G 451 P	Bioinformatics	2	4		50	50
2.	G 452 P	Applied Microbial Genetics	2	4		50	50
3.	G 453 P	**A.** Cell & Tissue Engineering **B.** Genetic Toxicology	2	4		50	50
4.	G 454 P	Project Thesis Presentation	2	4		50	50
		Total	**24**	**32**			**600**
		GRAND TOTAL	**96**	**128**			**2400**

MSc GENETICS II YEAR
SEMESTER- III
THEORY PAPER-I
G 301 T- GENETIC ENGINEERING

Unit 1: Gene manipulation and cloning vectors

1.1 Properties and applications of DNA modifying enzymes - restriction endonucleases & types (Type I to type IV); host controlled restriction modification system, isoschizomers
1.2 Modifying enzymes- methyltransferses, polymerases, kinases, phosphatases, nucleases, reverse transcriptase, terminal transferase and ligases
1.3 Cloning vectors- properties of cloning vectors
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
1.5 High-cloning capacity vectors- single stranded DNA vectors (M13),YACs, BACs, PACs
1.6 Hosts used in genetic engineering, prokaryotic hosts- *Escherichia coli*, *Bacillus subtilis* and Eukaryotic hosts –Yeast

Unit 2: Construction of genomic and cDNA libraries

2.1 Generalized cloning strategies
2.2 Strategies for construction of genomic libraries
2.3 Positional cloning- chromosome walking & chromosome jumping
2.4 Construction of subtractive and normalized cDNA libraries & its advantages
2.5 PCR primer design – gene specific primers, nested primers, degenerate primers, optimization of PCR components and thermal conditions, types of PCR – inverse PCR, nested PCR & RACE-PCR

Unit 3: Selection and screening of recombinant clones

3.1 Genetic selection- insertional inactivation and alpha complementation
3.2 Principle of hybridization- northern, southern & western blotting, dot-blot & colony hybridization, colony PCR
3.3 Labeling of nucleic acids- end labeling [3□-& 5□-], random priming & nick translation using radioactive & non-radioactive probes
3.4 Immunological screening
3.5 Isolation of individual genes by complementation assay & contig assembly
3.6 DNA sequencing methods- Maxam-Gilbert and Sanger's method, automated sequencing, multiplex sequencing
3.7 Next Generation Sequencing- principle & its applications

Unit 4: Analysis of recombinant clones

4.1 Mapping of restriction sites, S1 mapping
4.2 Site directed mutagenesis (mis-incorporation of mismatched oligo & mis-repair of mutant oligonucleotides, PCR-based method)
4.3 Screening of cloned genes (hybrid arrest and hybrid released translation)
4.4 Gene silencing technology, antisense, siRNA & microRNA
4.5 Transgenic, gene knock-in & knock-out technologies
4.6 Applications of genetic engineering in agriculture, animal husbandry, medicine & industry

PRACTICALS

G 351 P: GENETIC ENGINEERING

1. Isolation of plasmid
2. Restriction digestion and gel electrophoresis- plasmid
3. Restriction mapping problems
4. Polymerase chain reaction- genomic DNA
5. Cloning of target gene
6. Expression of cloned gene

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
5. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor)- M. R. Green, J. Sambrook

SEMESTER – III
THEORY PAPER- II
G 302 T- IMMUNOGENETICS

Unit 1: Basic principles and overview of the immune System

1.1 Types of immunity: innate immunity- anatomic, physiological, phagocytic and endocytic barriers; inflammation, anti microbial substances; Acquired immunity -active and passive immunity

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)

1.3 Organs of the immune system- primary lymphoid organs (bone marrow & thymus); secondary lymphoid organs (lymph nodes, spleen & mucosal-associated lymphoid tissue, cutaneous associated lymphoid tissue)

1.4 Antigens- immunogenicity versus antigenicity, factors that influence immunogenicity

1.5 Epitopes- properties of B-cell and T-cell epitopes

1.6 Haptens and the study of antigenicity, haptens and hapten-carrier conjugates

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

2.2 Immunoglobulin classes- IgG, IgM, IgA, IgD & IgE; functions of Ig classes, effector functions of immunoglobulins–APCC, complement, neutralization, opsonization

2.3 Organization and expression of immunoglobulin light and heavy chain genes- antibody diversity, isotype

2.4 B-cell activation & proliferation by thymus- independent & thymus-dependent antigens- *in vivo* sites for induction of humoral response; B cell differentiation, class-switching and generation of plasma cells & memory cells

2.5 Generation of polyclonal antibodies and applications (immunosupression & rabbit anti-thymocyte globulin); Generation of monoclonal antibodies and applications (abzymes, immunotoxins & monoclonal imaging)

2.6 B cell immunodeficiency disorders- X-linked agammaglobulinemia, selective immunoglobulin deficiency

Unit 3: Major Histocompatibility Complex

3.1 General organization and inheritance of MHC- organization of MHC class I & II genes, MHC haplotype

3.2 Structures of MHC class I and II molecules; peptide binding of MHC molecules

3.3 MHC molecules- cellular distribution & immune responsiveness

3.4 Polymorphisms of MHC class I and II molecules and its implication in diseases

3.5 Transplantation- relation between donor and recipient; types of grafts; bone marrow & hematopoietic stem cell transplantation

3.6 Role of HLA typing in organ transplantation

Unit 4: T- Cell mediated immune responses

4.1 Antigen processing by antigen presenting cells: endogenous antigens- cytosolic pathway; exogenous antigens- endocytic pathway

4.2 Structure and functions of T-cell receptor; T-cell receptor complex (TCR-CD3, T-cell accessory molecules), Ternary TCR-Peptide-MHC complex

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- Perforin mediated and Fas mediated pathways; Experimental assessment of cell mediated cytotoxicity- MLR, CML, GVH

4.4 Cytokines- general properties & biological functions; Cytokine secretion by T_H1 & T_H2 subsets, Cytokine antagonists; Delayed-type hypersensitivity (DTH) and cytokines involved in DTH

4.5 Autoimmunity and mechanisms of auto-immune disorders- Insulin dependent diabetes mellitus (IDDM), Rheumatoid Arthritis (RA) and Systemic Lupus Erythematosus (SLE)

4.6 Immuno-deficiency disorders- Congenital Immunodeficiency disorders (Severe combined Immunodeficiency (SCID), Digeorge Syndrome); Acquired Immunodeficiency Disorders (AIDS)

PRACTICALS

G 352 P: IMMUNOGENETICS

1. ABO blood typing
2. Microhaemagglutination
3. Single Radial Immunodiffusion
4. Isolation of lymphocytes and cell culture
5. Microlymphocytotoxicity assay
6. ELISA
7. HLA typing by PCR
8. Western Blot
9. FACS

REFERENCE BOOKS

1. Essential Immunology by I.Roitt, Publ:Blackwell
2. Immunology by G. Reever & I.Todd, Publ:Blackwell
3. Immuno diagnostics by S.C.Rastogi, Publ:New Age
4. Immunology by Richard A.Golds by, Thomas J Kindt, Barbaraa. Osborne, Janiskuby
5. Fundamental immunology by William E.Paul
6. Basic Immunology by Bhoosreddy G.L. and Wadher B.J.
7. Text book of immunology by Baruj Benacerraf
8. Immunology by Kuby: Publ:Freeman

SEMESTER-III
THEORY PAPER-III (ELECTIVE-1)
G 303 T (1A): HUMAN GENOMICS AND MEDICAL GENETICS

Unit 1: Human Genomics

1.1 Human genome architecture: Basic anatomy of human genome, Gene and genome diversity, Gene families, Human mitochondrial genome organization
1.2 Human genome projects: Goals, Strategies, Accomplishments, Applications and ethical considerations of Human genome project, 1000 Genome project, The HapMap project, The ENCODE project, Human functional genomic projects
1.3 Functional Genomics: Transcriptomics, Epigenomics and Proteomics
1.4 Applications of genomics in research, Society and public health: Comparative genomics, Pharmacogenomics, Clinical genomics, DNA fingerprinting and forensics, Nutritional genomics

Unit 2: Human genome analyses

2.1 Identification of human genome variations via whole genome, exome, transcriptome and epigenome analyses
2.2 Genome function analysis: Regulatory mechanisms in gene expression, Molecular explanation for dominance and recessive nature, Molecular mechanisms for pleiotropism, X-chromosome inactivation; Genomic imprinting
2.3 Techniques and tools for genome analyses: Advanced sequencing techniques, DNA and transcriptome profiling (Microarrays, SAGE, Small RNA sequencing), Loss-of-function techniques (Mutagenesis, RNAi), Bioinformatics tools (for obtaining reference human genome, Functional annotations for genes)
2.4 Genomic basis of Human disease: Genome variation and rare diseases, Genome variation and complex diseases
2.5 Cancer genomics: Analysis of driver and passenger variants, challenges in resolving inter and intra tumor heterogeneity

Unit 3: Genetic testing and genomic screening for diseases

3.1 Genetic counseling and risk assessment, need for genetic testing, levels of genetic testing
3.2 Prenatal screening (Indications, Invasive methods and Non-invasive techniques, Detection of cytogenetic, biochemical and genetic defects in fetal samples)
3.3 Neonatal Screening (PKU, Galactosemia, SCA & Congenital hypothyroidism)
3.4 Preclinical screening: Adult onset diseases (Alzheimer's, Huntington's disease & FHCL), Disease susceptibility for complex diseases (CAD, T2DM & RA)
3.5 Heterozygote detection and population screening (Thalassemias, Cystic Fibrosis, DMD, Fragile– X syndrome, Hemophilia)
3.6 Methods and approaches for genetic testing: biochemical assays, chromosomal analysis, molecular tests (detection for known & unknown mutations, analysis of dynamic mutations and gene expression analysis)
3.7 Markers for disease diagnosis and prognosis: Genetic markers, Protein/enzyme markers and antibodies; Use of biosensors and nanoparticles

Unit 4: Therapy for Genetic Diseases

4.1 Conventional methods for treatment of genetic diseases: Diet replacement, dietary avoidance, protein/enzyme substitution, diversion, replacement, transplantation; Recombinant gene products for therapy

4.2 Gene therapy: Criteria for gene transfer (*in vivo*, *in vitro* & *ex vivo* strategies), Somatic cell gene therapy vs germ line gene therapy, Gene transfer methods for therapy, Limitations of gene therapy, Approaches for Gene therapy (Gene Augumentation Therapy, Anti-sense therapy, Gene editing, Direct/ Indirect cell killing, Strategies for enhancing immune response and drug sensitivity, Microencapsulation)

4.3 Clinical trials: Adenosine Deaminase deficiency (ADA), FHC, CF and Solid tumors

4.4 Immunotherapy: Approaches in immune therapy (use of Monoclonal antibodies, NK cells, Dendritic cells, B lymphocytes and vaccines)

4.5 Nanomedicine: Therapeutic applications of nanoparticles, medical nanobiosensors, implications and challenges in nanomedicine

4.6 Pharmacogenomics: Single gene disorders (G6PD), Multigenic diseases (CHD), benefits of pharmacogenomics

PRACTICALS

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

1. Genotyping of selective markers – RFLP /Microsatellite/VNTR markers
2. Mutation detection by SSCP/Sequencing
3. Mutation screening by ARMS PCR
4. Problems on Genetic counseling and risk assessment
5. Triple marker test
6. RT-PCR analysis for identification of disease gene expression
7. Analysis of genome data

RECOMMENDED BOOKS

1. Connor & Smith. Essentials of Medical Genetics, Blackwell-1993
2. Davies Human. Genetic Disease Analysis, IRL-1993
3. Emery & Mueller. Elements of Medical Genetics, ELBS-1992
4. Jorde et al. Medical Genetics, Elsevier-1998
5. MaroniMolecular and Genetic Analysis of Human Traits. Blackwell-2001
6. Nussbaum et al. Genetics in Medicine, Saunders-2001
7. Pasternak. An Introduction to Molecular Human Genetics, Fritzgerald-2000
8. Prichard & Korf. Medical Genetics at a glance, Blackwell-2004
9. Strachan & Read. Human Molecular Genetics,Wiley-1999
10. Vogel & Motulsky. Human Genetics, Springer-1997
11. Sudbery. Human Molecular Genetics, Prentice-Hall 2002
12. Coleman & Tsongalis. Molecular Diagnosis, Humana-1997
13. Hawley and Mori. The Human Genome, Academic-1999
14. Geoffrey S. Ginsburg and Huntington F. Willard. Genomic and Personalized Medicine, Elsevier-2013
15. Das, Undurti N. Molecular Basis of Health and Disease, Springer-2011

SEMESTER-III
THEORY PAPER-III (ELECTIVE-1)
G 303 T (1B): ANIMAL GENETICS AND MOUSE MODELS

Unit 1: Animal Genetics & Breeding

1.1. Chromosomes- special type of chromosomes, chromosome number– live stock, laboratory animals, birds.
1.2. Meiosis and gametogenesis - chromosomes and sex determination.
1.3. Quantitative genetics– values and means; variance; resemblance between relatives; heritability and repeatability, genetic and phenotypic correlations.
1.4. Systems of mating: Inbreeding– relationship coefficients; outcrossing and cross breeding
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.
1.6. Genetic testing for disorders – genetic information, chromosomal abnormalities, breeding scheme – recommendations, individual identification and parentage testing, genome maps, identifying genetic mutations, disease testing

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.
2.2 *Ex-situ* and *in-situ* conservation of animal genetic resources– cryoconservation- methods
2.3 Reproductive endocrinology – endocrine tissues, endocrine hormones, estrous cycle.
2.4 Artificial insemination, ICSI, Oocytes, embryo transfer, ONBS, MOET technology in animal breeding.
2.5 Synchronization, superovulation and IVM/IVF embryo production, *in vitro* embryo production and micromanipulation of embryos; Sperm and embryo sexing.
2.6 Transgenesis- methods of production of transgenic animals; agriculture applications, biomedical applications- molecular farming & pharmanimals
2.7 Animal cloning- somatic cell nuclear transfer, cloning for research.

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.
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 Characterization of cell lines: morphology, chromosome analysis, DNA content, enzyme activity, antigenic markers, differentiation
3.4 Cell transformation: DNA transfer– calcium phosphate, lipofection, electroporation, nucleofection and viral vectors
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
3.6 Stem cells– different types, embyronic and adult stem cells, iPS cells, gene targeting to stem cells

Unit 4: Mouse in Biomedical Research

4.1 Mouse development- potency, commitment, specification, induction, competence, determination and differentiation, morphogenetic gradients, cell fate and cell lineages, stem cells, production of gametes, fertilization, zygote formation

4.2 Embryonic development- cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in mouse. Allopheny

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

4.4 Cancer models (carcinogen injection models, bone marrow transplantation models, xenograft models, retrovirus, lentivirus and adenovirus-based tumor models, transposon-based genome targeting, transgenic tumor models, double transgenic models)

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)

4.6 Infectious disease models: Mouse models of *Streptococcus* and *HIV*, Genetic susceptibility to infectious diseases, Humanized mouse and its applications; Metabolic disease models: Non-obese diabetic mouse, ob/ob mouse, mouse models of metabolic syndrome

PRACTICALS

G 353 P (1B): ANIMAL GENETICS & MOUSE MODELS

1. Laboratory animal species maintenance & specific utility- mice, rat, guinea pig, rabbit, dog and monkey
2. Mating methods- monogamous, polygamous and others
3. Genetic control and monitoring- record keeping
4. Management & use of laboratory animals- ethics and legislation
5. Strains and inbred lines- nomenclature.
6. Animal facility maintenance, mouse handling and ear-marking
7. Collection of blood, Intra-peritoneal and tail-vein injection.
8. Karyotype of farm animal species/blood group typing/DNA fingerprinting

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) 2nd edition, vol. III Normative Biology, Husbandry and Models. Editors Fox et al., Elsevier

SEMESTER-III
THEORY PAPER-IV (ELECTIVE-2)
G 304 T (2A): PLANT GENOMICS & BIOTECHNOLOGY

Unit 1: Plant Genomics

1.1. Plant nuclear genome- genome organization in plant nucleus, plant epigenome
1.2. Plant organellar genomes- plastid and mitochondrial genomes.
1.3. Plant genome sequencing strategies for plant genome sequencing, high-throughput sequencing technologies, single molecule and real time sequencing, assembly & alignment programs, genome browsers
1.4. Plant proteomics- high throughput approaches– mass spectrometry based proteomics
1.5. Plant metabolomics- analytical platforms– GC-MS, NMR, MALDI
1.6. Plant genome editing and genome engineering- ZFN, TALENs, CRISPR-Cas9 and ODM

Unit 2: Plant Secondary Metabolism & Metabolic Engineering

2.1 Secondary metabolites- ecological functions & uses
2.2 Terpenoids- synthesis of IPP, phenyltransferase and terpene synthase reactions, modification of terpenoid skeletons
2.3 Alkaloids- biosynthesis
2.4 Phenolic compounds- phenylpropanoid, phenylpropanoid-acetate pathways – biosynthesis
2.5 Lignans, flavonoids- biosynthesis
2.6 Coumarins, stilbenes, styrylpyrones and arylpyrones
2.7 Plant metabolic engineering- approaches to metabolic engineering- biotechnological application of alkaloid biosynthesis, phenolics metabolic engineering, terpenoids metabolic engineering.

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
3.2 Plant cell culture technique- callus and cell suspension cultures; applications of plant cell cultures
3.3 Somatic embryogenesis- induction of somatic embryos, production and applications of synthetic seeds
3.4 Cryo-preservation- theoretical basis, methods and applications of cryo-preservation.
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
3.6 Mass cultivation of plant cell and organ culture- modes of bioreactor operations, different types of bioreactors, hybrid reactors and disposable bioreactors
3.7 Hairy root cultures – large scale culture of hairy roots, applications; shooty teratomas and production of secondary metabolites

Unit 4: Transgenic Technologies

4.1 Co-integrated vectors, binary vectors, types of promoters, reporter genes, novel and specialized vectors for plant transformation.

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.

4.3 Chloroplast transformation- advantages of chloroplast transformation; transplastomic plants - applications.

4.4 Molecular farming- advantages of transgenic plants as bioreactors, expression systems, sub-cellular targeting (protein targeting), optimization of plant production systems, plant expression hosts, downstream processing & purification

4.5 Molecular farming for biopharmaceuticals (plantibodies, plantigens, therapeutic proteins & edible vaccines)

4.6 Molecular farming for industrial products (industrial enzymes, lysozyme, biopolymers, biofuel, paper manufacturing)

PRACTICALS

G 354 P (2A): PLANT GENOMICS AND BIOTECHNOLOGY

1. Genome browsers/ Real time PCR
2. TLC for screening of plant extracts/ extracting bioactive substances from plants
3. Preparation of different types of standard tissue culture media (MS and White's medium)
4. Induction of callus and initiation of cell suspension cultures
5. Cryopreservation/ Production of synthetic seeds
6. Induction of hairy roots through *Agrobacterium rhizogenes* mediated transformation/ Plant cell immobilization and biotransformation for secondary metabolite production.
7. Determining copy number in transgenic plants
8. Gateway cloning

REFERENCE BOOKS

1. From Plant Genomics to Plant Biotechnology (2013) edited by Palmiro Poltronieri, Natalija Burbulis, Corrado Fogher, Woodhead Publishing 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 Amita Sarkar, Discovery Publishing House Pvt. Ltd.
6. Metabolic Engineering of Plant Secondary Metabolism (2000) edited by Robert Verpoorte, A.Wilhelm Alfermann, Springer
7. Biochemistry and Molecular Biology of Plants (2015) edited by Bob B. Buchanan, Wilhelm Gruissem, Russell L. Jones, Wiley Blackwell

SEMESTER-III
THEORY PAPER-IV (ELECTIVE-2)
G 304 T (2B): PLANT NUTRACEUTICALS AND NUTRIGENOMICS

Unit 1: Phytochemicals: classification, biosynthesis and production

1.1 Secondary metabolites and phytochemicals –function of secondary products in plants, health benefits of phytochemicals.

1.2 Phytochemical classes and chemical properties: alkaloids, glycosides, flavanoids, phenolics, saponins, tannins, anthraquinones, essential oils, steroids; polyphenols, carotenoids, glucosinolates, terepens, lectins, polyacetylenes, allium compounds, capasicinoids, betalins.

1.3 Biosynthetic pathways of principle secondary product classes –Terpenoid and shikimate pathways, isoprenoid pathway, polyketide pathway; occurrence, chemistry, properties and biosynthesis of coumarins, phenolic compounds, flavonoids, carotenoids, lignans.

1.4 Plant cell biotechnology for production of secondary metabolites –*in vitro* techniques for the cultivation of nutraceutical plants, *in vitro* plants for production of secondary metabolites, 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)

1.5 Phytochemicals in plant cell bioreactors – plant bioreactors; commercial production of plant secondary metabolites.

1.6 Hairy root culture for secondary metabolites production – *A. rhizogenes* transformed medicinal plants for metabolite production, bioreactors and hairy root culture.

Unit 2: Nutrigenetics and Nutrigenomics

2.1 Nutritional genetics *vs* nutritional genomics

2.2 Nutrients modulating genome expression – nutrient as signal molecule, mechanisms of nutrient perception

2.3 Nutrigenetic diseases and Nutrigenomic diseases – PKU, Obesity, CVD, Cancer, Inflammation, Diabetes, Osteoporosis

2.4 Variation in human populations - gene polymorphism, SNP, nutritional implications; personalized nutrition

2.5 Biomarkers – biomarkers of biological effect - enzyme function, oxidative stress, immune function, bone health, cell turnover; biomarkers for genetic susceptibility

2.6 MicroRNAs as dietary bioactive compounds – characteristics, biogenesis and functions.

Unit 3: Advanced Tools in Nutrigenomics

3.1 Genetic selection- insertional inactivation and alpha complementation

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

3.3 Transcriptomics- mRNA profiling, cDNA-AFLP, DNA microarrays, SAGE, MIAME/Nut; using transcriptomics to explain mechanism behind differences in response to diet

3.4 Proteomics- 2D-DIGE, ELISA, protein microarray, MALDI-TOF, PSI (Proteomics Standard Initiative) – role of proteomics in nutrigenetics and nutrigenomics

3.5 Metabolomics- analytical tools– LC resolved and GC resolved mass spectrometry, NMR spectroscopy, global *vs* targeted metabolic profiling- applications to nutrition, metabolomics.

3.6 High throughput genomic screening – control of gene expression, methods of target validation (cell line testing, animal models) screening models
3.7 Bioinformatics– screening for bioactive nutrients and compounds, genome annotation, gene prediction, DNA motifs.

Unit 4: Phytochemicals and Nutraceuticals in Health & Disease

4.1 Nutraceuticals- isoprenoid derivatives, phenolic compounds, carbohydrate derivates, amino acid derivatives and minerals (Ca, Zn, Cu, K, Se)
4.2 Nutraceuticals and antioxidant function- oxidative stress and ROS, antioxidants (aminoacids, peptides and proteins), antioxidant defense systems, phytochemicals
4.3 Phytochemicals and cancer- models of carcinogenesis, cancer risk - nutrients and phytochemicals; impact on cancer metastasis suppressor genes, downstream signaling pathways modulation- epigenetics, phytoestrogens
4.4 Phytochemicals in immune function- carotenoids and flavonoids
4.5 Plant lipids in health and disease; plant tochopherols/tocotrienols and health
4.6 Functional foods in prevention of human health disorders- cancer prevention
4.7 Biofortification with phytochemicals; probiotics- prebiotics, synbiotics

PRACTICALS

G 354 P (2A): PLANT NUTRACEUTICALS AND NUTRIGENOMICS

1. Extraction of phytochemicals
2. Analysis of antioxidant capacity of phytochemicals
3. Chromatographic separation and detection of phytochemicals
4. *In vitro* cultivation technique of nutraceutical plants
5. Induction of callus and initiation of cell suspension cultures
6. Hairy root transformation for production of secondary metabolites
7. Gene polymorphism- SNPs and gene expression analyses
8. Gene prediction & DNA motifs

REFRENCE BOOKS

1. Nutrigenetics and Nutrigenomics (2004) edited by Simopoulos and Ordovas, Karger
2. Phytochemicals of Nutraceutical Importance (2013) edited by Dhan Prakash, Girish Sharma, CAB International
3. Phytochemicals: Nutrient-Gene Interactions (2006) edited by Mark S. Meskin, Wayne R. Bidlack, R. Keith Randolph, CRC, Taylor & Francis
4. Functional Foods, Nutraceuticals and Degenerative Disease Prevention (2011) edited by Gopinadhan Paliyath, Marica Bakovic, Kalidas Shetty, Wiley-Blackwell
5. Nutrition and Immunology: Principles and Practice (2000) edited by M. Eric Gershwin, J. Bruce German, Carl L. Keen, Springer

.

SEMESTER IV
THEORY PAPER-I
G 401 T: BIOINFORMATICS

Unit 1: Foundations of Bioinformatics

1.1 Bioinformatics- a historical perspective

1.2 Bioinformatics data – Nucleic acid sequence, protein sequence, protein structure, genome variation data, gene expression data, proteomic data, metabolic pathways and networks

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)

1.4 Database Search methods: key word, accession number and sequence based searches, search engines (Entrez and SRS)

1.5 Bioinformatics tools and resources- role of internet, free online tools, downloadable free tools, software packages

1.6 Bioinformatics web portals (NCBI, EBI & Xpasy)

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 DNA vs Protein Sequence alignment: permissible replacements, similarity score, Scoring matrices (PAM & BLOSUM)

2.3 Pairwise alignment: Dot-matrix comparison of sequences, Dynamic programming based Pairwise alignment algorithms (Global– Needleman-Wunch algorithm, Local– Smith-Waterman algorithm)

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

2.5 Multiple-sequence alignment: Significance of MSA, Progressive and Iterative alignment based algorithms for multiple sequence alignment

2.6 Multiple sequence alignment based database searching: Consensus sequence, nucleotide distribution matrix, sequence profile and Position specific scoring matrix, Profile BLAST

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)

3.2 Transcript-profiling: Expression microarrays (gene array, oligo array); Transcriptome sequencing and RNA-seq analysis, Small RNA sequencing and analysis

3.3 Genome annotation: finding repeats, gene finding in prokaryotes and eukaryotes, finding promoters and regulatory motifs

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)

3.5 Genome variation studies: identification of whole genome duplications and its implications, segmental duplication (copy number variation) identification and its implications, single nucleotide variation identification and its implications

3.6 Medical applications of Bioinformatics: Bioinformatics for understanding diseases, identification of disease genes and disease diagnostics; overview of drug discovery & pharmacogenomics

Unit 4: Applications of Bioinformatics in Proteomics and Metabolomics

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

PRACTICALS

G 451 P: BIOINFORMATICS

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
7. Bioinformatics: Concepts, Skills & Applications By R.S. Rastogi
8. Bioinformatics: Methods And Applications Genomics, Proteomics And Drug Discovery By S. C. Rastogi, Parag Rastogi, Namita Mendiratta

SEMESTER-IV
THEORY PAPER-II
G 402 T- APPLIED MICROBIAL GENETICS

Unit 1: Biology & Genetics of Microorganisms

1.1 Bacteria - classification, structure & function of bacterial cells, general life cycle, bacterial genetics (plasmids, conjugation, transduction, transformation)
1.2 Virus - classification, virion structure, general viral life cycle (phage virus reproduction – lytic & lysogenic cycle), viral genetics (mutations, recombination, reassortment, complementation, phenotypic mixing)
1.3 Fungi - classification; structure; fungal life cycles (*Aspergillus*) – types; fungal genetics (mating systems, outcrossing, non-outcrossing, parasexual cycle)
1.4 Protozoan - structure; classification; life cycle (*Trypanosoma*); protozoan genetics (genetic exchange in *Trypanosoma brucei*, *Leishmania*)
1.5 Algae - structure, life cycle (*Chlamydomonas reinhardtii*), tetrad analysis, zygote plating

Unit 2: Agricultural applications

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

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
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
3.3 Microbial biofuel production- bioethanol, biodiesel, biohydrogen
3.4 Microbial detection of pollutants, microbial degradation of organic compounds that generate environmental problems
3.5 Microbial bioremediation- engineering bacteria for bioremediation, bioaugmentation

Unit 4: Medical applications

4.1 Genetic & molecular basis of pathogenesis: bacterial (*Vibrio cholera*), viral (*HIV*), fungal (*Candida*), protozoan (malaria), prions (BSE)

4.2 Emerging & re-emerging infectious diseases/pathogens- epidemiology, pathogens- acute respiratory diseases, acute diarrheal illnesses

4.3 Molecular diagnosis of pathogens- methods and applications

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

4.5 Phamaceuticals & 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

PRACTICALS

G 452 P: APPLIED MICROBIAL GENETICS

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) by Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattern. ASM Press

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

Unit 1: Cell differentiation tissue development and cell culture

1.1 Basics of growth and differentiation- cell morphology, cell determination & differentiation, tissue organization, tissue components, tissue types
1.2 Dynamic states of tissues, homeostasis in highly prolific tissues & tissue repair, matrix molecules & ligands, Cell- ECM interactions, cell junctions in tissues
1.3 Measurement of cell characteristics - cell morphology, cell number and viability, cell-fate processes, cell motility, cell function
1.4 Response to mechanical stimuli, inductive phenomena (instructive and permissive), morphogenesis & regeneration
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
1.6 Animal cell culture (media, culture environment & maintenance of cells *in vitro*, primary cells vs. cell lines)

Unit 2: *In vivo* & *in vitro* tissue and organ development

2.1 Patterning of cells and their environment, biological testing of biomaterials
2.2 Cell-polymer interactions, effects of matrix on cells, considerations for the design of artificial organs
2.3 Organotypic and histiotypic models, collagen gel model
2.4 Factors influencing transplantation of engineered tissues and organs, Graft rejection (Leucoderma, Burns, & Liver cirrhosis)
2.5 Fetal tissue engineering
2.6 Tissue engineering bioreactors – classification and design

Unit 3: Cells & biomaterials for tissue engineering

3.1 Stem cells – types (embryonic stem cells, adult stem cells), characteristics and properties (totipotencey & pluripotencey)
3.2 Tissue engineering scaffolds matrices (bio-compatible, absorbable, degradable, porosity, mechanical properties & biomimitics)
3.3 Biomaterials for tissue engineering- natural materials- polysaccharides (agarose, gelatin), proteins (collagen, silk) and synthetic materials–polymers (PLA PGA)
3.4 Bioprinting technologies - 2D & 3D-architecture of scaffolds
3.5 Synthesis of scaffolds (electro-spinning)
3.6 Tissue engineering triad

Unit 4: Tissue engineering organs, prospects and ethical issues

4.1 Structure and functions of the engineering tissues- bone/joint replacements, cartilage, tendons, ligaments
4.2 Soft tissue engineering- skin
4.3 Regeneration of internal organs- liver
4.4 Regeneration of cornea
4.5 Prospects of tissue engineering
4.6 Regulatory and ethical issues

PRACTICALS

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

1. Tissue culture basics-Sterilization of Tissue culture components, Preparation of tissue culture media RPM1-1640/MEM/DMEM, Filtration of tissue culture media
2. Tissue culture/ Cell culture maintenance- Maintenance of tissue culture, Sub culturing (Trypsinization, Passaging & Seeding)
3. Cell counting and Viability assay- Counting cells on heamocytometer, Trypan blue exclusion test, MTT assay to determine the metabolic activity of cell
4. Cell invasion and migration assay- Cell culture wound closure assay
5. Colony formation assay

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

SEMESTER-IV
THEORY PAPER-III (ELECTIVE-3)
G 403 T (3B): GENETIC TOXICOLOGY

Unit 1: Genetic toxicology

1.1 History of genetic toxicology- role of genetic toxicology in health effect testing
1.2 Cell cycle and chromosome mechanics in somatic and germ cells – somatic vs germ cells, chromosome, mitotic cell cycle, meiosis & chromosome mechanics
1.3 DNA damage and repair- post-replication repair, excision repair, base replacement, deletions and insertions
1.4 Mutagenesis- single nucleotide point mutations, intercalating frame shift mutagens, cross-linking mutagens, clastogenic mutagens
1.5 Carcinogenesis- physical, chemical and biological agents; mechanisms of carcinogenesis, oncogenes or tumor suppressor genes, chromosomal abnormalities leading to cancer, epigenetic carcinogens
1.6 Consequence of genotoxic effects in humans and other mammals- gene pool consequences, relationship of genotoxic effect to other toxicologic phenomena
1.7 Applications of genetic toxicology- human & environment monitoring

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)
2.2 *In vitro* gene mutation & chromosome mutation – mouse lymphoma forward mutation assay (L5178Y/*Tk*+/-), *Tk* gene mutation assay
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
2.4 Chromosome aberration (germ cells)– mammalian spermatogonial chromosome aberration test, *in vivo* chromosomal aberration tests- rodent bone marrow chromosomal effects
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
2.6 *In vitro*/*In vivo* DNA damage – Sister chromatid exchange in mammalian cells; *In vitro* DNA adducts – DNA adduct analysis

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
3.2 Gene mutation in *Saccharomyces cerevisiae*; *in vitro* cytogenetic assay – mitotic recombination in *Saccharomyces cerevisiae*
3.3 *In vivo* cytogenetic assay – drosophila sex-linked recessive lethal test; Genome mutation assays –specific locus test in *Neurospora*
3.4 Mammalian cell transformation (*in vitro* carcinogenesis)– BALB/c-3T3 cells, C3H 10T1/2 cells
3.5 Novel assays– gamma-H2AX, GADD45a-GFP Green Screen
3.6 Biomarkers– application of biomarkers for human risk assessment
3.7 Nongenotoxic carcinogen mechanisms – kidney cancer in male rats & alpha-2 microglobulin nephropathy, mouse liver tumors, peroxisome proliferation, dioxin & aryl hydrocarbon receptor

Unit 4: Evaluation of genetic toxicity with plant systems and 'omics'

4.1 Carcinogens in plants – mycotic toxins, mushroom toxins, streptomyces toxins
4.2 Genotoxicity & carcinogenicity of herbal products – volatile alkenylbenzenes, anthraquinones
4.3 Genotoxic agents in agro-ecosystem– mutagenicity and carcinogenicity of pesticides
4.4 Plant dependent mutation assays - higher plant genetic systems for screening & monitoring mutagens
4.5 Transgenic plants for environmental pollution genotoxicity – transgenic systems, marker genes used for mutation assay
4.6 *In silico* approaches– QASR computational toxicology, *Ab initio* molecular models for genotoxicity
4.7 Toxicogenomics– high throughput screening of genotoxicity- ToxTracker assay

PRACTICALS

G 453 P (3B): GENETIC TOXICOLOGY

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

REFERENCE BOOKS

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 Olavi Pelkonen, Pierre Duez, Pia Maarit Vuorela, Heikki Vuorela

G 404 T: PROJECT WORK

G 454 P: PROJECT THESIS PRESENTATION