SRM
UNIVERSITY
(Under section 3 of UGC Act 1956)

M. Tech. Genetic Engineering (Full Time)
Curriculum & Syllabus (2013-2014)

Department of Genetic Engineering
School of Bioengineering
Faculty of Engineering & Technology
SRM University, Kattankulathur, Chennai
Tamil Nadu, India 603 203

DEPARTMENT OF GENETIC ENGINEERING
SRM UNIVERSITY
M.Tech GENETIC ENGINEERING (FULL TIME)
CURRICULUM & SYLLABUS (2013-2014)

SEMESTER- I

Code	Category	Course	L	T	P	C
GN2001	C	Molecular Genetics	3	0	3	4
GN2002	C	Biological Chemistry	3	0	3	4
GN2003	C	Immunobiology	3	0	3	4
GN2004	S	Advanced Biostatistical Methods	2	2	0	3
PE-1	PE	Program Elective 1	3	0	0	3
Total			14	2	9	18

SEMESTER-II

Code	Category	Course	L	T	P	C
GN2005	C	Recombinant DNA Technology	3	0	3	4
GN2006	C	Regulation of Gene Expression	3	0	3	4
GN2007	C	Sequence Analysis & Structure Prediction	3	0	3	4
PE-2	PE	Program Elective 2	3	0	0	3
PE-3	PE	Program Elective 3	3	0	0	3
IE-1	IE	Interdisciplinary Elective	3	0	0	3
Total			18	0	9	21

SEMESTER- III

Code	Category	Course	L	T	P	C
PE-4	PE	Program Elective-4	3	0	0	3
PE-5	PE	Program Elective-5	3	0	0	3
PE-6	PE	Program Elective-6	3	0	0	3
GN2047	C	Seminar	0	0	1	1
GN2048	C	Project Work - Phase I	0	0	12	6
Total			9	0	13	16

SEMESTER-IV

Code	Category	Course	L	T	P	C
GN2049	C	Project Work - Phase II	0	0	32	16
Total			0	0	32	16
TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE M.TECH DEGREE						71

C – Core Course
S- Supportive Course
PE- Program Elective
IE- Interdisciplinary Elective

CONTACT HOUR/CREDIT:

L: Lecture Hours per week **T: Tutorial Hours per week**

P: Practical Hours per week **C: Credit**

Program Electives

Course Code	Name of the course	L	T	P	C
	I SEMESTER				
GN2101	Advanced Human Physiology	3	0	0	3
GN2102	Plant Physiology and Development	3	0	0	3
GN2103	Microbial Physiology	3	0	0	3
	II SEMESTER				
GN2104	Genomics and Proteomics	3	0	0	3
GN2105	Developmental Genetics	3	0	0	3
GN2106	Microbial Genetics	3	0	0	3
GN2107	Metabolic Engineering of Microbes	3	0	0	3
GN2108	Plant-Environment interaction	3	0	0	3
GN2109	Plant Metabolism	3	0	0	3
	III SEMESTER				
	MODULE 1: MEDICAL GENETICS				
GN2110	Pharmacogenetics	3	0	0	3
GN2111	Cancer Genetics	3	0	0	3
GN2112	Reproductive Genetics	3	0	0	3
	MODULE 2: PLANT GENETICS				
GN2113	Plant Cell and Tissue Culture	3	0	0	3
GN2114	Transgenic Plants: Methods and	3	0	0	3

Course Code	Name of the course	L	T	P	C
	Applications				
GN2115	Classical and Molecular Plant Breeding	3	0	0	3
	MODULE 3: MICROBIAL GENETICS				
GN2116	Molecular Virology	3	0	0	3
GN2117	Metagenomics	3	0	0	3
GN2118	Molecular Pathology of Infectious Disease	3	0	0	3

Course Code	Course Title	L	T	P	C
GN2001	MOLECULAR GENETICS	3	0	3	4
	Total Contact Hours - 90				

PURPOSE	
To learn the fundamentals molecular genetics and its application in biology.	
INSTRUCTIONAL OBJECTIVES	
1.	Understand the relationship between classical genetics and its genotype
2.	Understand the central dogma of life
3.	Understand the molecular genetics of model organisms and its application

THEORY

UNIT I - FUNDAMENTALS OF GENENTICS (9 hours)

Mendelian inheritance: Mendel's laws - Chromosomes and heredity: linkage and linkage groups - Gene: gene concept, unit of function, replication, recombination and repair, transposable elements – complementation analysis - rII locus, inborn errors of metabolism, one gene/one enzyme hypothesis, pathways of gene action.

UNIT II - GENOME ORGANIZATION (9 hours)

Genome organization in prokaryotes and eukaryotes - DNA content and C-value paradox - methods to measure DNA content variation - various types of DNA sequences – simple sequences, repetitive sequences, tandem gene clusters, satellites, Cot curve, DNA structures: double helix, Z-DNA, B-DNA, mechanism of DNA replication: prokaryotes and eukaryotes.

UNIT III - MECHANISM OF TRANSCRIPTION (9 hours)

Mechanism of transcription: prokaryotes and eukaryotes - Operon and operon concept - Eukaryotic gene structure and expression - Mechanism of translation: prokaryotes and eukaryotes, Control of gene expression - RNA processing and editing, transcriptional, post transcriptional, translational and post transnational controls

UNIT IV- MOLECULAR GENETICS OF PHAGE AND YEAST (9 hours)

Phage molecular genetics: genetic organisation - lytic and lysogenic cycle, regulation of genes - T-odd coliphages – ss DNA phages – RNA phage. Yeast molecular genetics: genome - mutants and genetic screens – genetic redundancy – cell type determination – cell cycle regulation of mitotic events – genetic interaction: two hybrid systems – gal pathway, gene regulation.

UNIT V- MOLECULAR GENETICS OF DROSOPHILA (9 hours)

Drosophila molecular genetics: genome - development genetics – mutants and genetic screens – P element biology –construction and use of genetic mosaics. Mouse molecular genetics: directed gene expression – gene dosage compensation – gene replacement and knockout.

LABORATORY EXPERIMENTS (45 hours)

1. Analysis of genetic markers in bacteria
2. Measurement of growth rate; One step growth curve using a even phage
3. Induced mutagenesis and isolation of antibiotic resistant and auxotrophic mutants
4. Enrichment for antibiotic resistant and auxotrophic mutants
5. Genetic mapping by P1 transduction
6. Genetic mapping by conjugation
7. Isolation of specialized transducing phage
8. Transposon mutagenesis

REFERENCES

1. L. Snyder, Molecular Genetics of Bacteria, Blackwell Publishing Company, Oxford, UK. Third Edition (2007).
2. J.R. Johnston, Molecular Genetics of Yeast - A Practical Approach, Oxford University Press, UK First Edition (1994).
3. S.B. Primrose and R.M. Twyman, Principles of Genome Analysis and Genomics, Blackwell Publishing Company, Oxford, UK Third Edition (2003).
4. L M. Silver Mouse genetics: Concepts and Applications, Oxford University Press, First Edition (1995).
5. W.H.H. Lodish, A.Berk, and C.A. Kaiser, “Molecular Cell Biology”, Freeman & Co Ltd. Third edition (1995).
6. J.D. Watson, T.A. Baker, S. P. Bell, A. Gann, M. Levine, R. Losick, “Molecular Biology of the Gene”, Pearson Education Inc, Fifth Edition (2004).

MANUALS

1. A. Sambrook, and D.W. Russel, Molecular Cloning. A Laboratory Manual. Volume 1-3. Cold Spring Harbor Laboratory Press, New York, USA, Third Edition (2001).

Course Code	Course Title	L	T	P	C
GN2002	BIOLOGICAL CHEMISTRY	3	0	3	4
	Total Contact Hours – 90				

PURPOSE	
To learn the chemical basis of biological system.	
INSTRUCTIONAL OBJECTIVES	
1.	To understand the chemistry and metabolic disorders of carbohydrates and lipids
2.	To understand the chemistry and metabolic disorders of proteins and nucleic acids
3.	To give an knowledge on hormones and their functions and disorders
4.	To understand the principle applications analytical techniques.

UNIT I - CARBOHYDRATES AND LIPIDS (10 hours)

Carbohydrates and lipids – Classification and metabolism - metabolic disorders - Biochemistry of Diabetes mellitus, Glycogen storage diseases, disorders of lipid metabolism

UNIT II - PROTEIN AND NUCLEIC ACIDS (9 hours)

Protein and nucleic acids – Biochemistry, functions and metabolic disorders, PEM, biogenic amines, neurotransmitters, nucleic acid metabolism - inhibitors and disorders.

UNIT III - STEROID HORMONES (8 hours)

Hormone - General mechanism of action of hormones, chemistry, synthesis of steroid hormones, functions. Disorders –hyper and hypo conditions.

UNIT IV - PEPTIDE HORMONES AND AMINOACID DERIVATIVES (8 hours)

Cell signaling - Hormone receptors, polypeptide hormones, & thyroid hormones. Chemistry & functions. Hormones of pancreas, and parathyroid. Local hormones. Clinical disorders of hormones.

UNIT V -ANALYTICAL TECHNIQUES (10 hours)

Principles, instrumentations and applications of NMR, HPLC, FPLC, GC, GC-MS, LC-MS, MALDI-ToF.

LABORATORY EXPERIMENTS (45 hours)

1. Preparations of solutions buffers and measurement of pH
2. Analysis of isoenzymes
3. Analysis of blood glucose level
4. Analysis of blood total proteins
5. Protein purification using FPLC
6. HPLC
7. GC

REFERENCES

1. MN Chatterjea, Shinde Rana, "Textbook of Medical biochemistry" jaypee brothers medical publications 8 the edition, 2011.
2. D. Voet and J.G. Voet, "Fundamentals of Biochemistry". Wiley Publishers Second Edition (2005)
3. A.L. Lehninger, D.L. Nelson, and M.M. Cox, "Principles of Biochemistry", W. H. Freeman Publications Fifth Edition (2008)
4. Laboratory Manual

Course Code	Course Title	L	T	P	C
GN2003	IMMUNOBIOLOGY	3	0	3	4
	Total Contact Hours - 90				

PURPOSE	
To introduce the science of immunology and detailed study of various types of immune systems and methods used in immunology.	
INSTRUCTIONAL OBJECTIVES	
1.	To understand the basic concepts of immunology
2.	To know about transplantation immunology and auto immunity
3.	To learn the methods used in immunology (immunotechniques)

THEORY

UNIT I - CONCEPTS OF IMMUNOLOGY (9 hours)

General principles of immune system, molecules, cells and tissues of immune system, primary and secondary lymphoid organs (thymus, bursa of fabricius, lymph nodes, spleen), B and T lymphocyte and their functions, lymphocyte cell mediated cytotoxicity.

UNIT II - ANTIGENS AND ANTIBODIES (9 hours)

Concepts of antigen, antigenic determinant, antigenicity, immunogen and immunogenicity, factors affecting antigenicity, hapten, carrier effect, cross reactivity, adjuvtants, Freund's adjuvants and its significance, immunoglobulin, structure of immunoglobulin, types and properties of immunoglobulin, theories of antibody formation, clonal selection, Ig genes, immunoglobulin synthesis and metabolism, and antibody diversity.

UNIT III - HUMORAL AND CELL MEDIATED IMMUNITY(9 hours)

MHC, MHC antigen- Class I, Class II, Class III, antigen presentation, MHC restriction, immune response gene, immune response, humoral and cell mediated immune response, BCR, TCR & generation of biodiversity, lymphocytes, T cells regulation, graft rejection.

UNIT IV - ANTIGEN- ANTIBODY REACTION (9 hours)

Physico-chemical basis of Ag-Ab interaction, avidity, strength of binding between Ag and Ab and its measurement, detection of Ag-Ab interaction, precipitation, agglutination and complement fixation, complement system, and cytokines.

UNIT V - IMMUNOTECHNIQUES (9 hours)

One and two dimensional, single radial immuno diffusion, Ouchterlony immno diffusion, rocket immunoelectrophoresis, CIE, Graber and William technique, direct and indirect agglutination, ELISA, Direct, indirect and Sandwich immunofluorescence, hybridoma technology and monoclonal antibodies, Abezyme technique, Antiserum production, immuno histocompatibility, location of cells in tissues, immunoblotting, flow cytometry.

LABORATORY EXPERIMENTS (45 hours)

1. Antibody production
2. ELISA
3. Western blotting
4. Flowcytometry.
5. Single Radial Immuno Diffusion
6. Double diffusion.
7. Rocket Immunoelectrophoresis.
8. Counter- Current Immunoelectrophoresis.
9. Characterization of Immunoglobulins by SDS-PAGE

REFERENCES

1. P. Delves, S. Martin, D. Burton and I. Roitt, Essential Immunology, Wiley-Blackwell Publishers, UK , Eleventh Edition (2006).
2. J. Kuby, Immunology, W H Freeman & Co Publishers, Third Edition (1997).
3. F.C. Hay and O.M.R. Westwood, Practical immunology, Wiley-Blackwell Publishers Fourth Edition (2002).
4. Immunology - A Short Course, Third Edition E. Benjamin, G. Sunshine, and S. Leskowitz, "Wiley-Liss Publishers", New York. (1996).
5. Fourth Edition D.P. Stites, J.D. "Basic and Clinical Immunology", Stobo and J.V. Wells, Appleton & Lange Publishers. (1982)

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Course Code	Course Title	L	T	P	C
GN2004	**ADVANCED BIOSTATISTICAL METHODS**	**2**	**2**	**0**	**3**
	Total Contact Hours - 60				

PURPOSE

The purpose of the course is to impart knowledge on different advanced bio-statistical methods for its applications in bio-engineering related disciplines. The emphasis will be more on solving practical problems with basic understanding of the theoretical concepts.

INSTRUCTIONAL OBJECTIVES

	At the end of the course, the students should able to understand
1.	Analysis of biological data to draw valid inferences
2.	To understand the working of statistical methods and its applications to several situations
3.	To develop statistical models and to study the several characteristics of biological data structures

UNIT I - BASIC STATISTICAL MEASURES, CORRELATION AND REGRESSION (12 hours)

Basic ideas of Measures of central tendency, Measures of dispersion, Skewness and Kurtosis. Correlation and Regression theory, Testing the significance of an observed correlation coefficient, observed regression

coefficient and observed partial regression coefficient, Testing difference between to partial regression coefficient, Multiple regression model.

TUTORIALS

(i) Computation of Mean, Median, Mode, Standard Deviation, Coefficient of Variation, Coefficient of Skewness.
(ii) Test for Correlation coefficient and Regression coefficient
(iii) Test for partial regression coefficient and for the difference between two partial regression coefficient
(iv) Construction of a Multiple Regression Model

UNIT II - CONTINGENCY TABLES (12 hours)

Chi-square Test-2x2 tables, rxc tables, McNemar's test, The odd ratio, Berkson's fallacy.

Multiple 2x2 contingency tables: Simpson's Paradox, The Mantel-Haenszel method, Test of homogeneity, Test of association.

TUTORIALS

(i) McNemar's test to evaluate hypothesis about the data.
(ii) Computation of The Odd Ratio and Simson's Paradox.
(iii) Mantel-Haenszel method to combine the information in a 2x2 table.

UNIT III - TWO SAMPLE HYPOTHESIS (12 hours)

Testing for difference between two means, Testing for difference between two variances, Two sample Rank Testing – The Mann – Whitney Test, Testing for difference between two Median.

TUTORIALS

(i) One tailed hypothesis and two tailed hypothesis for a two sample T-test
(ii) An one tailed variance ratio test and two tailed variance ratio test
(iii) One tailed Mann-Whitney Test

UNIT IV- MULTI-SAMPLE HYPOTHESIS (12 hours)

A single factor Analysis of Variance, The Kruskal–Wallis single-factor analysis of variance by ranks. Bartlett's test for homogeneity of variances,Testing for homogeneity of coefficient of variation.

TUTORIALS

(i) Kruskal-Wallis test
(ii) Bartlett's test
(iii) Test for homogeneity of coefficient of variation

UNIT V- MULTIPLE COMPARISONS (12 hours)

The Tukey test – The Newman-Keuls test – Dunnett's test - Scheffe's Multiple Contrast.

TUTORIALS

(i) The Tukey test with unequal sample sizes
(ii) The Newman-Keuls multiple range test
(iii) Dunnett's test for comparing a control mean to each other group mean
(iv) Scheffe's test for multiple contrast

REFERENCES

1. Jerold H.Zar, "*Bio-statistical Analysis, Pearson Education Inc., Dorling"*Kindersley (India) Pvt. Ltd., New Delhi, 4th Edition 2009.
2. Marcello Pagano and Kimberlee Gaurveau, Principles of "*Bio-Statistics*", Duxbury, Thomson Asia Pvt. Ltd., Singapore, 2004.
3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye: "*Probability & Statistical for Engineers and Scientists*", Pearson Education, Inc., Dorling Kindersley (India) Pvt. Ltd., New Delhi, 2007.

SEMESTER II

Course Code	Course Title	L	T	P	C
GN2005	RECOMBINANT DNA TECHNOLOGY	3	0	3	4
	Total Contact Hours - 90				

PURPOSE	
To learn the molecular techniques that is required to be a successful genetic engineer of plants, animals and microorganisms.	
INSTRUCTIONAL OBJECTIVES	
1.	To learn the gene cloning methods in theory and practice
2.	To learn genetic engineering of living organism for human benefit

THEORY

UNIT I - ENZYMES AND VECTORS IN GENE CLONING (9 hours)

Restriction enzymes, methylases, DNA polymerases, reverse transcriptase, terminal transferase, alkaline phosphatase, polynucleotide kinase, ligase, DNase and RNase. Structural and functional organization of plasmids, plasmid replication, stringent and relaxed plasmids, incompatibility of plasmid maintenance. Lambda phage vectors.

UNIT II- POLYMERASE CHAIN REACTION (12 hours)

PCR, gene isolation by PCR, primer design – gene specific primers, nested primers, degenerate primers, optimization of PCR components and thermal conditions, PCR set up with proper controls, types of PCR – inverse PCR, nested PCR, TAIL PCR, LAMP, cloning of PCR products – TA cloning, blunt end cloning, TOPO cloning, cloning with added restriction sites, GATEWAY cloning, semi quantitative RT-PCR, real-time PCR with SYBR and Taqman probe, site directed mutagenesis (PCR and non-PCR methods).

UNIT II - GENE CLONING METHODS (8 hours)

Cohesive end cloning, blunt end cloning, cloning using adapters, linkers and homopolymer tailing, GATYWAY cloning, ligation free cloning, Construction of cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library.

UNIT IV- GENE & PROMOTER ISOLATION (8 hours)

Methods of screening the libraries using nucleic acid and antibody probes, functional screening, screening by complementation, cloning of genes by PCR, RT-PCR, RACE-PCR, artificial gene synthesis, constitutive and

inducible promoters, tissue specific promoters, promoter identification from gene expression data, promoter deletion studies, reporter genes for promoter deletion studies.

UNIT VI - GENETIC ENGINEERING OF LIVING ORGANISMS

(8 hours)

Expression and purification of recombinant proteins in E.coli, yeast, Baculovirus, animal
cell lines, transgenic plants and transgenic animals.

LABORATORY EXPERIMENTS **(45 hours)**

1. Designing cloning strategies
2. Cloning using restriction enzymes
3. Cloning of PCR products
4. Cloning in expression vector
5. Induction of expression of recombinant protein
6. Purification of recombinant proteins using His Tag
7. Automated DNA sequencing

REFERENCES

1. S.B. Primrose, S.B. and R.M. Twyman, “Principles of Gene Manipulation and Genomics”, Blackwell Publishing Company, Oxford, UK Third Edition (2006).
2. T.A. Brown, Gene Cloning and “DNA Analysis: An Introduction”, Wiley-Blackwell, UK. Fifth Edition (2006).
3. M. Innis, T. White and J.J. Sninsky, PCR Protocols: A Guide to “Methods and Applications”, Academic Press First Edition (1990).
4. S. Ying, Generation of cDNA Libraries: “Methods and Protocols”, Humana Press First Edition (2003)

MANUALS

1. Sambrook, and D.W. Russel Molecular Cloning. A Laboratory Manual, Cold Spring Harbor Laboratory Press, New York, USA. Volume 1-3. Third Edition(2001)
2 F.M. Ausubel, R. Brent, R.E. Kingston and D.D. Moore, Current Protocols in Molecular Biology, John Wiley & Sons, Inc., Brooklyn, New York., First Edition (1987)

Course Code	Course Title	L	T	P	C
GN2006	REGULATION OF GENE EXPRESSION	3	0	3	4
	Total Contact Hours - 90				

PURPOSE	
To understand the mechanisms of control of gene expression	
INSTRUCTIONAL OBJECTIVES	
1.	To learn basics of gene expression
2.	To learn transcriptional, translational, post-transcriptional and post-translational regulation of gene expression

THEORY

UNIT I - INTRODUCTION TO GENE EXPRESSION (9 hours)

Fine structure of gene, transcription and translation in prokaryotes and eukaryotes. Epigenetic regulation- histone modifications – histones and 5srRNA gene – histones and class II genes – nucleosome positioning - chromatin folding – remodeling – DNA methylation and imprinting.

UNIT II - TRANSCRIPTIONAL CONTROL OF GENE EXPRESSION (9 hours)

DNA sequence elements: Short sequence elements – enhancers – locus control regions, DNA protein interactions: zinc fingers – leucine zipper – basic helix loop helix – helix turn helix – homeodomain, transcriptional factor: categories of activators and activation mechanism – repressors and repression mechanism – DNA binding motifs of activators – interaction among activators – non coding RNA - nuclear receptors

UNIT III - TRANSLATIONAL CONTROL OF GENE EXPRESSION (9 hours)

mRNA cap and poly(A) tail interaction – upstream ORF control – regulation of ribosomal recruitment in eukaryotes – regulation of initiator met – tRNA – frame shifting, hoping and readthrough – control of elongation phase– internal ribosome entry site elements - sequence context of translation initiation – translational control during heat shock – ferritin synthesis

UNIT IV - POST-TRANSCRIPTIONAL CONTROL OF GENE EXPRESSION (9 hours)

mRNA stability - RNA editing - RNA export - mRNA decay in plants – Antisense – cosupression – RNAi - micro RNA – virus induced gene silencing.

UNIT V- POST TRANSLATIONAL GENE REGULATION (9 hours)

Modification of amino acid side chains – protein remodeling, methylation, acetylation, phosphorylation – GTPase switch proteins – ligand or co-factor binding – interaction with other proteins – protein targeting : nuclear localization and nuclear export signal – protein stability and degradation

LABORATORY EXPERIMENTS (45 hours)

1. Assay for gene induction
2. Assay for gene repression
3. RNA isolation
4. Northern analysis
5. RT PCR
6. Real time PCR
7. S1 nuclease mapping
8. Restriction mapping
9. Primer extension assay
10. C. elegans model for RNAi

REFERENCES

1. M. Carey and S.T. Smale, Transcriptional Regulation in Eukaryotes: Concepts, Strategies and Techniques, Cold Spring Harbor Laboratory Press. Second Edition (2001).
2. B. M. Turner, Chromatin and Gene Regulation: Molecular Mechanisms in Epigenetics, Wiley-Blackwell Publications, First Edition (2002).
3. D. S. Latchman, Gene Regulation: A Eukaryotic Perspective, Springer Publication Second Edition (2008).
4. J.Ma, Gene Expression and Regulation, Springer Publication, First Edition (2006).
5. W.H.H. Lodish, A.Berk, and C.A. Kaiser, “Molecular Cell Biology”, Freeman & Co Ltd, Third edition ,1995.
6. J.D. Watson, T.A. Baker, S. P. Bell, A. Gann, M. Levine, R. Losick, “Molecular Biology of the Gene”, Pearson Education Inc, Fifth Edition 2004.

MANUALS

1. Sambrook, and D.W. Russel Molecular Cloning. A Laboratory Manual, Cold Spring Harbor Laboratory Press, New York, USA. Volume 1-3. Third Edition 2001

Course Code	Course Title	L	T	P	C
GN2007	SEQUENCE ANALYSIS & STRUCTURE PREDICTION	3	0	3	4
	Total Contact Hours - 90				

PURPOSE	
Aims at providing an knowledge of various bioinformatics methods involved in sequence analysis and structure prediction	
INSTRUCTIONAL OBJECTIVES	
1.	To learn methods of sequence alignment
2.	To learn the methods of protein structure prediction and interaction analysis

THEORY

UNIT I- SEQUENCE ANALYSIS (9 hours)

Methods of sequence alignment: graphic similarity comparison; Dot plots; Hash tables; Scoring matrices – identify matrix, genetic code matrices (GCM); Substitution matrices, Mutation Data Matrices (MDM), Percentage accepted Mutation (PAM). Block Substitution Matrices (BLOSUM), mutation probability matrices; Sequence similarity searches and alignment tools – dynamic programming algorithms; Needlman-Wunch and Smith Waterman, Optimal global alignment and optimal local alignment; Whole genome transcript analysis and contig assembly

UNIT II - SEQUENCE ALIGNMENT (12 hours)

Concept; Programmes (Dot matrix, Dot plot, Dynamic programming) ; Similarity Searches ; Sequence repeats and inversion; Database searching (BLAST and FASTA.Multiple Sequence alignment (MSA) – significance; softwares (PIMA, Clustal, Pileup, ClustalW, Meme, MACAW), Whole genome assembly – de novo assembly and reference assembly, comparative genomics.

UNIT III - PHYLOGENETIC ANALYSIS (6 hours)

Phylogenetics, cladistics and ontology; Phylogenetic representations – graphs, trees and cladograms; Steps in phylogenetic analysis; Methods of phylogenetic analysis – similarity and distance tables, distance matrix method; Method of calculation of distance matrix (UPGMA, WPGMA); The Neighbour Joining Method; The Fitch/Margoliash method; Character-based

Methods – maximum parsimony, maximum likelihood; Phylogenetic softwares – PAUP, PHYLIP, MacClade.

UNIT IV - PROTEIN STRUCTURE PREDICTION (9 hours)

Prediction of protein secondary structure from the amino acid sequence – Chou-Fasman methods,Neural network models ,Mearest neighbor methods ,Hidden markov model.

UNIT V - PROTEIN-PROTEIN INTERACTIONS (9 hours)

Prediction of three dimensional protein structure-comparative modeling, threading and ab initio method, Homology modelling

LABORATORY EXPERIMENTS (45 hours)

1. Sequence Analysis Packages – EMBOSS, NCBI ToolKit
2. Dynamic programming.
3. Basic Blast and Specialized Blast, Multiple sequence alignment
4. MEME/MAST, eMotif, InterproScan, ProSite, ProDom, Pfam
5. Phylogenetic analysis – PAUP, PHYLIP, MacClade
6. De novo assembly of bacterial genome
7. Reference assembly of bacterial genome
8. Advanced Visualization Software and 3D representations.
9. Coordinate generations and inter-conversions.
10. Secondary Structure Prediction: Fold Recognition, ab initio (Rosetta Server), Homology based comparative protein modeling, Energy minimizations, Validation of models (WHATIF, PROSA, PROCHECK, VERIFY 3D), Protein Structure Alignment.

REFERENCES

1. D. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, New York, Second Edition (2004).
2. A.D. Baxevanis and B.F. Francis Ouellellette, Bioinformatics – A Practical Guide to the “Analysis of Genes and Proteins”, John Wiley & Sons**,** UK, Second Edition (1998)

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SEMESTER III

Course Code	Course Title	L	T	P	C
GN2047	**SEMINAR**	**0**	**0**	**1**	**1**

PURPOSE

To train the students in preparing and presenting technical topics.

INSTRUCTIONAL OBJECTIVE

The student shall be capable of identifying topics of interest related to the program of study and prepare and make presentation before an enlightened audience.

The students are expected to give at least two presentations on their topics of interest which will be assessed by a committee constituted for this purpose. This course is mandatory and a student has to pass the course to become eligible for the award of degree. Marks will be awarded out of 100 and appropriate grades assigned as per the regulations

Course Code	Course Title	L	T	P	C
GN2049	**PROJECT WORK PHASE I (III semester)**	**0**	**0**	**12**	**6**
GN2050	**PROJECT WORK PHASE II (IV semester)**	**0**	**0**	**32**	**16**

PURPOSE

To undertake research in an area related to the program of study

INSTRUCTIONAL OBJECTIVE

The student shall be capable of identifying a problem related to the program of study and carry out wholesome research on it leading to findings which will facilitate development of a new/improved product, process for the benefit of the society.

M.Tech projects should be socially relevant and research oriented ones. Each student is expected to do an individual project. The project work is carried out in two phases – Phase I in III semester and Phase II in IV semester. Phase II of the project work shall be in continuation of Phase I only. At the completion of a project the student will submit a project report, which will be evaluated (end semester assessment) by duly appointed examiner(s). This evaluation will be based on the project report and a viva voce examination on the project. The method of assessment for both Phase I and Phase II is shown in the following table:

Assessment	Tool	Weightage
In- semester	**I review**	**10%**
	II review	**15%**
	III review	**35%**
End semester	**Final viva voce examination**	**40%**

Student will be allowed to appear in the final viva voce examination only if he / she has submitted his / her project work in the form of paper for presentation / publication in a conference / journal and produced the proof of acknowledgement of receipt of paper from the organizers / publishers.

PROGRAM ELECTIVES

Course Code	Course Title	L	T	P	C
GN2101	ADVANCED HUMAN PHYSIOLOGY	3	0	0	3
	Total Contact Hours -45				

PURPOSE

To provide students with an understanding of the function and regulation of the human body and physiological integration of the organ systems to maintain homeostasis. In addition, the course would help students in understanding the molecular concepts involved in physiology.

INSTRUCTIONAL OBJECTIVES

1.	Know the experimental principles and methodologies involved in physiology.
2.	Gain knowledge in cellular processes involved in physiology.
3.	Understand the major elements and concepts that constitute neuro, muscular and endocrine systems.
4.	Understand the basic functions of cardiovascular and respiratory systems.
5.	Enable the students to appreciate the digestive and metabolic processes of macromolecules.

UNIT I - EXPERIMENTS AND MODELS IN PHYSIOLOGY(8 hours)

Methods and models in Experimental Physiology – Molecular and cellular techniques in experimental physiology. Biomolecules, Energy and metabolic regulation. Membrane structure and organization, Osmosis, Active and Passive transport, Cell Junction, Exocytosis and Endocytosis

UNIT II - NEUROPHYSIOLOGY AND ENDOCRINE SYSTEMS (12 hours)

Neuronal structure, functions, Membrane excitation, resting and action potentials. Neuronal communication – Neurotransmission – Synapses, Synaptic plasticity and Sensory reception. Organisation of neuromuscular junctions - Neuronal control of muscle contraction – cardiac, skeletal and smooth muscles. Neuroendocrine systems – Peptide and steroid hormones – Cellular signalling

UNIT III -CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY (8 hours)

Blood-Components of Blood-Blood clotting factors. The Heart – Peripheral circulation-Cardiac cycle–Cardiac output-The lymphatic system. Physiology of Respiration-Gaseous transport-Gaseous exchange.

UNIT IV - GASTROINTESTINAL AND THERMOREGULATORY PHYSIOLOGY (8 hours)

Alimentary system – Gastrointestinal secretions – Absorption – Energy metabolism. Renal blood flow- Thermogenesis – Regulation of body temperature-Osmoregulation

UNIT V - RENAL AND REPRODUCTIVE PHYSIOLOGY (9 hours)

Glomerular filtration rate- Formation of Urine-Acid Base balance, Osmotic balance, Water balance. Male and Female Reproductive systems-Sexual reproduction – Sex determination – Oogenesis and Spermatogenesis – Fertilization – Reproductive cycle in Mammals

REFERENCES

1. W.F. Boron and E.L. Boulpaep "*Medical Physiology*", Saunders Publications, Updated Edition (2005).
2. Randall, Burggren, French "*Animal Physiology"*– 4th edition
3. A.C. Guyton and J.E. Hall, "*Medical Physiology*", Saunders Publications, Eleventh Edition (2005).

Course Code	Course Title	L	T	P	C
GN2102	PLANT PHYSIOLOGY AND DEVELOPMENT	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
The goal of this course is to plant architecture, physiological processes and development of multicellular plant from zygote.	
INSTRUCTIONAL OBJECTIVES	
1.	Study anatomy and embryology of plants
2.	Study photosyntheisis and respiration
3.	Study growth and development of plants
4.	Study the hormonal regulation of plant growth

THEORY

UNIT I - PLANT ANATOMY (9 hours)

Meristems and meristematic growth – anatomy of root, stem, leaf, flower, fruit and seed

UNIT II - PLANT EMBRYOLOGY (9 hours)

Stamen and Androecium - Pollen Development - Carpel and Gynoecium - Ovule and Embryo Sac - Pollination and Pollen-Stigma Interaction – Pollen tube germination, growth and Fertilization - Endosperm - Embryo.

UNIT III - PLANTS, WATER, AND MINERALS (9 hours)

Whole Plant Water Relations - Plants and Inorganic Nutrients - Roots, Soils, and Nutrient Uptake - Transporter Systems - Translocation in the Phloem

UNIT IV - PHOTOSYNTHESIS AND RESPIRATION (9 hours)

The Light Reactions - Mode of Action of Some Herbicides - Dark Reactions - Oxidative Photosynthetic Carbon Cycle – C2, C3, C4, and CAM cycle – Respiration -Utilization of Oil Reserves in Cotyledons.

UNIT V - LIGHT AND HORMONAL CONTROL OF PLANT GROWTH (9 hours)

Photoperiodism - Phytochrome Regulation of Gene Expression - Blue-Light Responses - Guard Cell Osmoregulation – Auxin - Growth Hormone – Gibberellins - Regulators of Plant Height – Cytokinins - Regulators of Cell Division – Ethylene - Gaseous Hormone - Abscisic Acid - A Seed Maturation and Antistress Signal - Circadian Rhythms.

REFERENCES

1. F. Salisbury and C. Ross, “Plant Physiology”, Brooks Cole Publisher, Fourth Edition (1991)
2. L. Taiz and E. Zeiger, “Plant Physiology”, Sinauer Associates Inc.Fourth Edition (2006)

Course Code	Course Title	L	T	P	C
GN2103	MICROBIAL PHYSIOLOGY	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To learn the fundamental concepts of microbial physiology	
INSTRUCTIONAL OBJECTIVES	
1.	To know about the structure and organization of microorganisms
2.	To know about the response of microbes to environmental stress
3.	To know about signal transduction and communication in microbes

UNIT I - CELL STRUCTURE AND FUNCTION (9 hours)

Biosynthesis of peptidoglycan - outer membrane, teichoic acid – Exopolysaccharides; cytoplasmic membrane, pili, fimbriae, S-layer. Electron carries – artificial electron donors – inhibitors – uncouplers – energy bond – phosphorylation. Bacterial nucleoid, Microbial cell surfaces –peptodoglycan, slime layer, outer membrane proteins of Gram negative bacteria, Enterobacterial antigens,

UNIT II - MICROBIAL GROWTH (9 hours)

Phases of growth curve – measurement of growth – calculations of growth rate – generation time – synchronous growth – induction of synchronous growth, synchrony index – factors affecting growth – pH, temperature, substrate and osmotic condition. Survival at extreme environments – starvation – adaptative mechanisms in thermophilic, alkalophilic, osmophilic and psychrophilic. Bioluminescence - mechanism –advantages

UNIT III - MEMBRANE TRANSPORT (9 hours)

The composition and architecture of membranes, Membrane dynamics, Solute transport across membranes: Passive diffusion, active transport using P and F type ATPases, Ion mediated transport, transport of ions across membranes (ion pumps), Model membranes; Liposomes

UNIT IV - MICROBIAL STRESS RESPONSES (9 hours)

Osmotic stress and osmoregulation, Osmotic control of gene expression, Oxidative stress response and its regulation, pH stress and acid tolerance, thermal stress and heat shock response, gene expression in response to nutrient and starvation stress, stringent control.

UNIT V - BACTERIAL CELL DIVISION AND SIGNAL TRANSDUCTION (9 hours)

Bcaterial cell division in Gram negative rods and Gram positive coci, Global control networks, two component regulatory systems, regulation of nitrogen assimilation and fixation, phosphate uptake and its regulation, Quorum sensing and proteomic control.

REFERENCES

1. Moat and Foster , "Microbial Physiology", John Wiley & Sons 4th edition, 2002
2. Lansing M. Prescott, "Microbiology", Macmillan Publishers 5th edition.

Course Code	Course Title	L	T	P	C
GN2104	GENOMICS AND PROTEOMICS	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To learn the structure and functions of the genomes together with the approaches to analyze the genomes and proteome.	
INSTRUCTIONAL OBJECTIVES	
1.	To know the computational approaches to analyze the genomes and proteome
2.	To understand genome maps and types
3.	To learn the basics of protein-protein interactions

UNIT I - ORGANIZATION OF THE PROKARYOTIC AND EUKARYOTIC GENOMES (9 hours)

Genome maps and types; current sequencing technologies; partial sequencing; gene identification; gene prediction rules and software; Genome databases; Annotation of genome. Genome diversity: taxonomy and significance of the following genomes: bacteria, yeast, Caenorhabditis, Homo sapiens, Arabidopsis, etc.

UNIT II - MICROARRAY (9 hours)

Methods for gene expression analysis; DNA array for global expression profile; Types of DNA array, Array databases; Applications of DNA microarray, Differential gene expression under varying conditions and during development of Drosophila and C. Elegans.

UNIT III - HUMAN GENOME (9 hours)

Mapping of Human Genome; Construction of physical maps; Basics of radiation hybrid maps; Sequencing of the entire human genome, annotation and analysis of genome sequences: sequence repeats, transposable elements, gene structure, pseudogenes; Implications of the Human Genome Project; Basics of Single Nucleotide Polymorphisms, detection and its implications.

UNIT IV - THE PROTEOME AND PROTEOME TECHNOLOGY (9 hours)

Introduction, Expression proteomics (express profile); Cell map proteomics; Protein separation technology - 2D-Gel Electrophoresis, liquid chromotagraphy, affinity chromatography (for cell map proteomics); mass spectroscopy and its uses in protein identification; Forward and Reverse Proteomics.

UNIT V - PROTEIN-PROTEIN INTERACTIONS (9 hours)

Yeast two hybrid, Co-Precipitation, Phage Display, Phylogenetic Profile, Domain fusion, Gene Neighborhood, Gene Cluster, Mirror Tree, Analysis of genome wide Protein-Protein Interactions in yeast, Genome wide yeast two hybrid analysis of other organisms, Protein fragment complementation assays.

REFERENCES

1. S.B. Primrose and R.M. Twyman, "Principles of Genome Analysis" and Genomics, Blackwell Publishing Company, Oxford, UK. Third Edition (2003).
2. D.C. Liebler, "Introduction to proteomics"– Tools for The New Biology, Humana Press Inc, New Jersey, USA First Edition (2002).
3. Timothy Palzkil, Proteomics, 'Kluwer Academic Publishers", Massachusetts, USA Second printing (2002).
4. A.D. Baxevanis and B.F. Francis Ouellellette," *Bioinformatics – A Practical"* Guide to the Analysis of Genes and Proteins, John Wiley & Sons, UK First Edition (1998).

Course Code	Course Title	L	T	P	C
GN2105	**DEVELOPMENTAL GENETICS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
PURPOSE					
To learn developmental genetics at advanced level.					
INSTRUCTIONAL OBJECTIVES					

1.	To give an overview about advanced developmental genetics
2.	To enable the understanding of gene expression and functions during development, differentiation and sex determination

UNIT I - OVERVIEW OF ADVANCED EVELOPMENTALGENETICS (9 hours)

Genetics of development, phases in development, embryo genetics, role of genes in several developmental stages, understanding development in genetic terms.

UNIT II - GENETICS OF CORE OF DEVELOPMENT (9 hours)

Embryological origins of gene theory, early attempts at developmental genetics, genome equivalence, determining the function of genes during development, Knockout experiments, antisense RNA

UNIT III - ROLE OF GENES IN DEVELOPMENT ANDDIFFERENTIATION (9 hours)

Cell-specific gene activation, Specificity in Eukaryotic transcription and Tissue Differentiation. Genetic regulation in prokaryotes and eukaryotes, messenger RNA and differentiation, circadian clock-Molecular biology of Drosophila embryogenesis.

UNIT IV - ROLE OF GENES IN SEX DETERMINATION (9 hours)

Dosage compensation and its mechanisms-Sex determination and events in Sex determination and differentiation-Noncoding DNA hypothesis for sex determination-Evolutionary relationships among sex determining mechanisms.

UNIT V - PATTERN FORMATION AND EPIGENETICS (9 hours)

Pattern formation and its impact on development. Positional information and developmental patterns-Epigenetics and DNA methylation. Epigenetic reprogramming and epigenetic code-Linking conventional genetics with development.

REFERENCES

1. G.S.Miglani "*Developmental Genetics*" 1st edition, I.K.International publishing house, 2011
2. James D. Watson, Tania A Baker, Stephen P Bell, Alexander Gann and Levine Michael, "*Molecular Biology of the Gene*" Pearson education, 2004
3. Lewis Wolpert, Cheryll Tickle, "*Principles of Development*", Oxford University Press, 2011

4. Alfonso Martinez Arias, Alison stewart, "*Molecular Principles of Animal Development*" Oxford University Press, 2002

Course Code	Course Title	L	T	P	C
GN2106	MICROBIAL GENETICS	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To enable the students to acquire knowledge about Microbial genetics.	
INSTRUCTIONAL OBJECTIVES	
1.	To know about the genetic organization of bacteria and viruses
2.	To know about the gene regulation in bacteria

UNIT I -DNA REPLICATION AND REPAIR MECHANISMS (9 hours)

Molecular mechanisms of DNA Replication – bidirectional and rolling circle replication. Differences in prokaryotic and eukaryotic replication. Plasmids – types, structure and replication. DNA repair – mechanism of excision repair, SOS repair and mismatch repair. Plasmids and types, plasmid replication and segregation, plasmid maintenance by host killing-role of ccd genes, conjugation, cis-trans complementation tests

UNIT II - DNA RECOMBINATION AND MUTATION (9 hours)

DNA recombination and models – general recombination, site specific recombination, restriction and modification systems, insertion sequences and transposable elements and examples, mutations and types

UNIT III - GENETICS OF BACTERIOPHAGE (9 hours)

General characteristics of bacteriophages, phage T4 – structure, gene expression and genome organization, λphage – replication, lytic and lysogenic cycles, transcription of phage genes, mechanisms of repressor synthesis and its control, autoregulation, use of phages as cloning vectors.

UNIT IV - TRANSCRIPTION AND TRANSLATION (9 hours)

Process of transcription – initiation, elongation – termination. Synthesis of mRNA in prokaryotes and eukaryotes. Synthesis of rRNA and tRNA. RNA processing – capping and polyadenylation. Genetic code, process of translation – initiation, elongation and termination. Signal sequences and protein transport.

UNIT V - STRAIN CONSTRUCTION (9 hours)

Construction of bacterial strains – isolation of sugar utilization mutants and thymine requiring mutants, selection for autotrophic deletion mutants, strain construction using existing strains, isolating transposon insertions in genes, using transposon insertions near genes, localized mutagenesis, production of

phage mutants, isolation of λ lambda mutants, use of phage to isolate operon and gene fusions.

REFERENCES

1. Moat and Foster, "Microbial Physiology", Wiley Liss publishers, 4th edition, 2002
2. Jeremy W. Dale and Simon F Park, "Molecular Genetics of Bacteria", John Wiley and Sons, 4th edition, 2004.

Course Code	Course Title	L	T	P	C
GN2107	**METABOLIC ENGINEERING OF MICROBES**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				

PURPOSE

To enable the students to acquire knowledge about the metabolic engineering of microbes. This also makes them to know the economic importance of engineered microbes.

INSTRUCTIONAL OBJECTIVES

1.	To make them understand the basic metabolic pathways of microbes
2.	To understand the regulation of metabolic pathways
3.	To get the knowledge of metabolically engineered organisms and products
4.	To know about the methods involved in metabolic engineering.

UNIT I - CELLULAR METABOLISM – OVERVIEW (9 hours)

Basic concepts of Metabolic Engineering - Overview of cellular metabolism; Transport processes, fuelling reactions: glycolysis, Fermentative pathways, Biosynthetic reactions, Polymerization, cellular energetics. Different models for cellular reaction for primary and secondary metabolites

UNIT II - REGULATION OF METABOLIC PATHWAYS (9 hours)

Regulation of enzyme activity, enzyme concentration: control of transcription initiation, control of translation; regulation at whole cell level and metabolic networks

UNIT III - METABOLIC ENGINEERING IN PRACTICE (9 hours)

Enhancement of product yield and productivity – ethanol, solvents and amino acid; extension of substrate range; extension of product spectrum and novel products – antibiotics, vitamins, pigments and biopolymers. Improvement of cellular properties and xenobiotic degradation.

UNIT IV - TOOLS OF METABOLIC ENGINEERING (9 hours)

Classical mutagenesis, Gene shuffling, gene knockout, gene silencing, transformation with vectors, quorum sensing, stimulation by precursors, gene insertion or deletion, heterologous expression of entire gene clusters

UNIT V - IMPORTANT ASPECTS OF METABOLIC ENGINEERING (9 hours)

Metabolic flux analysis, metabolic control analysis, analysis of structure of metabolic networks, flux analysis of metabolic networks, thermodynamics of cellular processes.

REFERENCES

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Metabolic engineering – "Principles and Methodologies", Jens Nielsen Academic Press , 1st Edition, 1998
2. Qiong cheng, "Microbial metabolic engineering: method"s and protocols, Humana press, 1st Edition, 2011.

Course Code	Course Title	L	T	P	C
GN2108	PLANT - ENVIRONMENT INTERACTION	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To understand the interaction of plant with its variable environment. To understand the response of plants to change in the environment both biotic and abiotic.	
INSTRUCTIONAL OBJECTIVES	
1.	To learn basics of signal perception and transduction in plants
2.	To learn the response in plant to biotic, abiotic and other environmental niche

UNIT I - PLANT GROWTH AND ENVIRONMENT (9 hours)

Signaling in plant gravitropism, signaling in phototropism, signaling in the circadian clock, sugars signaling and plant development;

UNIT II - PLANT AND ENVIRONMENTAL NICHE (9 hours)

Mechanical integration of plant cells; root behavior; communication and signaling – mycorrhiza, parasite, aminobutyrate and hydroxybutyrate;

nyctinasty; aposematic coloration; cognition; sexual deception; food deception; stomata movement

UNIT III - PLANT AND ABIOTIC STRESS INTERACTION (9 hours)
ABA stress signaling, regulation of ABA metabolism; auxin signaling and response; calcium sensing and signaling; ROS - ROS production and signaling of ROS; drought induced nitrogen signaling, ion homeostasis, glutathione homeostasis; miRNA signaling

UNIT IV - PLANT AND BIOTIC STRESS INTERACTION (9 hours)
Signal transduction - receptor-like kinases – gene families and function; MAPK families and functions; calcium activated kinase families; miRNA signaling; plant bacteria interaction – pathogenesis, symbionts; plant fungal interaction – pathogenesis, symbionts; plant virus interaction.

UNIT V - CROSS-TALK BETWEEN ABIOTIC AND BIOTIC STRESS RESPONSE (9 hours)
Biotic stress versus abiotic stress; ABA and jasmonic acid; auxin, cytokinin, and brassinosteroids; salicylic acid; DELLA proteins.

REFERENCES

1. Frantisek Baluska, Plant-Environment Interactions - From Sensory Plant Biology to Active Plant Behavior, Springer Berlin Heidelberg, 2009
2. Parvaiz Ahmad, M.N.V. Prasad , Abiotic Stress Responses in Plants - Metabolism, Productivity and Sustainability publisher - Springer-Verlag Berlin Heidelberg.
3. Frantisek Baluska, Stefano Mancuso, Signaling in Plants – “Signaling and Communication in Plants”, Springer Berlin Heidelberg, 2010.

Course Code	Course Title	L	T	P	C
GN2109	PLANT METABOLISM	3	0	0	3
	Total Contact Hours - 45				
PURPOSE					
To impart knowledge on basic secondary metabolic pathways in plants. To provide insight into primary and secondary metabolites with major and relatively minor functions in plants and humans.					
INSTRUCTIONAL OBJECTIVES					
1.	To gain knowledge on the metabolite function and biogenesis.				
2.	To provide a platform for students to understand metabolic pathways				

	in plants.
3.	To help students to understand metabolic pathways for further manipulation for any desired product

UNIT I - ALKALOIDS (9 hours)

Biochemistry, physiology and ecological functions of secondary metabolites, transport, storage and turnover. Biosynthesis of alkaloids and betalains , pyrrolizidine alkaloids (PAs), benzylisoquinoline alkaloids, monoterpene indole alkaloids (MIA), ergot alkaloids, acridone alkaloid biosynthesis, purine alkaloids, taxol, betalains.

UNIT II - CYANOGENIC GLYCOSIDES, GLUCOSINOLATES AND NON-PROTEIN AMINO ACIDS (9 hours)

Cyanogenic glycosides – structure, cyanogenesis and metabolism of cyanogenic glycosides. Glucosinolates, structure, biosynthesis, mustard oil formation, ecological significance and nutritional value. Non-protein amino acids- structure, metabolism and ecological significance.

UNIT III - PHENYLPROPANOIDS (9 hours)

General phenylpropanoid pathway and formation of hydroxycinnamate conjugates, phenylpropanoid-derived aroma and fragrance compounds. Coumarins- classification and recent advances, coumarin derivatives, furanocoumarins. Lignans - biosynthesis of monolignols, lignan and norlignan biosynthesis. Gallotannins and ellagitannins - biosynthesis of gallic acid and pentagalloylglucose, biosynthesis of gallotannins and ellagitannins,

UNIT IV - TERPENOIDS` (9 hours)

Function and biosynthesis, mevalonate pathway, methylerythritol phosphate pathway, assembly of C5 units into C10, C15 and C20, prenyl diphosphates, formation of parent carbon skeletons, secondary transformations.

UNIT V - STEROLS (9 hours)

Biosynthesis biotransformation, functions, transport and storage of sterols, cardiac glycosides, brassinosteroids, phytoecdysteroids and steroid saponins and steroid alkaloids

REFERENCES

1. Michael Wink, “Biochemistry of Plant Secondary Metabolism, Annual plant reviews” Vol. 40, Second Edition, Wiley Blackwell 2010.

SEMESTER III

Course Code	Course Title	L	T	P	C
GN2110	PHARMACOGENETICS	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To learn about pharmacogenomics principles, methods and applications	
INSTRUCTIONAL OBJECTIVES	
1.	To study about impact of polymorphism in human genome and applications
2.	To know about functional analysis of gene variation and genotyping techniques To study about the pharmacogenomics application in diseases
3.	To learn how to manage the pharmacogenomic information

THEORY

UNIT I - INTRODUCTION TO PHARMACOGENOMICS (9 hours)

Pharmacogenomics: Historical perspectives and current status, Human Genome and Genomic Applications, Genetic Polymorphism of Metabolic Reactions, SNPs, Association Studies in Pharmacogenomics.

UNIT II - FUNCTIONAL ANALYSIS OF GENE VARIATION (9 hours)

Transfection Assays With Allele-Specific Constructs: Functional Analysis of UDP-Glucuronosyltransferase Variants, CYP 2D6, CYP2C19 in drug metabolism, Snapshot of the Allele-Specific Variation in Human Gene Expression, Genome-Wide Analysis of Allele-Specific Gene Expression Using Oligo Microarrays, Roche Ampli Chip, HaploChIP: An In Vivo Assay.

UNIT III - GENOTYPING TECHNIQUES (9 hours)

Aspects Influencing Genotyping Method Selection, Denaturing HPLC for Mutation Detection and Genotyping, Pyrosequencing of Clinically Relevant Polymorphisms, Kinetic Fluorescence-Quenching Detection Assay for Allele Frequency Estimation, MALDI–TOF Mass Spectrometry, Fluorescence-Based Fragment Size Analysis, SNP Genotyping in DNA Pools, Genotyping of InDel Polymorphisms

UNIT IV - PHARMACOGENOMICS APPLICATION (9 hours)

Application of pharmacogenomics in Drug discovery, clinical trials, metabolism, cardiovascular diseases, Cancer treatment, Neurodegenerative diseases, Respiratory diseases, AIDS, Antibiotic therapy.

UNIT V -MANAGEMENT OF PHARMACOGENOMIC FORMATION (9 hours)

Pharm GKB: Pharmacogenetics and Pharmacogenomics knowledge Base, Systems for the Management of Pharmacogenomic Information, Internal and external databases (NCBI Gene, dbSNP, OMIM, Gene Ontology and KEGG databases.

REFERENCES

1. Federico Innocenti, Pharmacogenomics: Methods and Protocols (Methods in Molecular Biology), Humana Press Inc, New Jersey, USA First Edition, 2005.
2. Nadine Cohen Pharmacogenomics and Personalized Medicine (Methods in Pharmacology and Toxicology) Humana Press Inc, N,ew Jersey, USA First Edition, 2005.
3. M.C. Catania, An A-Z Guide to Pharmacogenomics, "American Association for Clinical Chemistry" First Edition, 2006.
4. Mark A. Rothstein, Pharmacogenomics: Social, Ethical, and Clinical Dimensions**,** Wiley-Liss Publications First Edition 2003.

Course Code	Course Title	L	T	P	C
GN2111	**CANCER GENETICS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
PURPOSE					
This course makes the students to understand the genetics of development of cancer					
INSTRUCTIONAL OBJECTIVES					
1.	To gain the knowledge on biology and genetics of cancer				
2.	To understand the molecular mechanism and instability involved in cancer development				

UNIT I - BIOLOGY OF CANCER (9 hours)

Development and causes of cancer: Types of cancer, Development of cancer, Causes of cancer, properties of cancer cells, Transformation of cells in culture. Tumor viruses: Hepatitis B Viruses, SV40 and Polyomaviruses, Papilloma viruses, Adenoviruses, Herpes viruses, Retroviruses.

UNIT II - GENETICS OF CANCER (9 hours)

Oncogenes: Retroviral oncogenes, Proto-oncogenes, Oncogenes in human cancer, functions of oncogene. Tumor suppressor genes: Functions of tumor suppressor genes, roles of oncogenes and tumor suppressor genes in tumor development. Cancer as a multistep process. Loss of heterozygosity. Case study of retinoblastoma (Rb)

UNIT III - MOLECULAR MECHANISMS IN CANCER (9 hours)

Types of mechanism – Epigenetics, Genetic Pathways, Apoptosis and DNA repair. Significance for understanding cancer. Case study of colon cancer (HNPCC). Mutagens and cancer. Ames test, Cigarette smoke and UV light.

UNIT IV - GENOMIC INSTABILITY OF CANCER (9 hours)

Breast cancer case study, Colorectal Cancers, Renal Cell Carcinoma. Multiple mutations and the evolution of metastases. Multiple mutations in cancer. Metastasis and angiogenesis. Genomic instability and cancer.

UNIT V - CANCER TREATMENT (9 hours)

Present and Future, Cancer therapy: Current Therapies. Therapies based on understanding the Loss of Cell cycle control. New Therapies, immunotherapy, gene therapy, Rational tailored medical treatments. Cancer drugs. Epidemiology and Cancer Prevention.

REFERENCES

1. Kenneth Offit, "Clinical cancer genetics: Risk counseling and management", 1st edition, 1998.
2. Fred Bunz, "Principles of cancer genetics", Springer science, 2008.

Course Code	Course Title	L	T	P	C
GN2112	REPRODUCTIVE GENETICS	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
This course makes students to acquire knowledge about the reproductive genetics, also the techniques involved in reproductive assistance.	
INSTRUCTIONAL OBJECTIVES	
1.	To make the students understand the reproductive physiology and genetics.
2.	To gain knowledge on reproductive genetic disorders

3.	To know about various techniques and diagnostic methods involved in reproductive genetics

UNIT I - REPRODUCTIVE PHYSIOLOGY (9 hours)

Physiology of male and female reproductive system. Reproductive endocrinology – role of hormones in reproduction system. Fertilization & Prenatal Development. Pregnancy and hormonal changes.

UNIT II - REPRODUCTIVE DISORDERS (9 hours)

Disorders of gonads, genital tracts and genitalia – Pseudo hermaphroditism, True hermaphroditism, Gonadal dysgenesis, Gender identity disorder. Anomalies of genital ducts. Infertility, Recurrent pregnancy loss.

UNIT III - GENETIC BASIS OF REPRODUCTIVE DISORDERS (9 hours)

Reproductive Genetics – genetics of sex determination & sexual differentiation, Genetic basis of male infertility, Genetic basis of female infertility.

UNIT IV - TECHNOLOGIES IN REPRODUCTIVE ASSISTANCE (9 hours)

Reproductive technologies, Artificial insemination, Cryopreservation of oocyte, sperm & embryo, in vitro fertilization, embryo transfer, Intra-cytoplasmic sperm injection

UNIT V - GENETIC TESTING AND ETHICAL IMPLICATIONS (9 hours)

Prenatal and Pre-implantation genetic diagnosis – Genetic testing. Current practice and future possibilities. Legal and Research ethical issues involving fetuses and embryos.

REFERENCES

1. Besser & Thorner. “Comprehensive clinical endocrinology”, Mosby, 2002
2. Sean Kehoe, “Reproductive Genetics”, RCOG Press, Ist edition 2009.

Course Code	Course Title	L	T	P	C
GN2113	PLANT CELL AND TISSUE CULTURE	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To learn the methods and techniques involved in plant tissue culture and micropropagation of plants.	
INSTRUCTIONAL OBJECTIVES	
1.	To learn about the conditions and nutrients required for plant cell and tissue culture.
2.	To know the methods for production of haploid and triploid plants.
3.	To learn about the occurrence of genetic changes in the process of plant tissue culture.

UNIT I - FUNDAMENTALS OF PLANT TISSUE CULTURE (9 hours)

Development of plant tissue culture techniques, cell behavior, pathogen free plants, germplasm storage, recalcitrant plants, work area, aseptic conditions.

UNIT II - PLANT NUTRIENTS AND HORMONES (9 hours)

Inorganic salts, plant growth regulators, vitamins, carbohydrates, gelling agent, aminoacids, antibiotics, natural complexes, media pH, types of media and preparation, micropropagation of plants, green house

UNIT III - REGENERATION OF EXPLANTS (9 hours)

Types of explants- parameters for explants selection - surface sterilization, direct and indirect organogenesis- callus induction, suspension cell culture, biotransformation, meristem culture and its applications.

UNIT IV - PROTOPLAST ISOLATION AND FUSION (9 hours)

Protoplast isolation, purification, types of protoplasts, culture media, protoplast regeneration, protoplast fusion, somatic hybrids and cybrids and their applications.

UNIT V - GENOTYPE AND TISSUE CULTURE (9 hours)

Somatic embryogenesis, anther/ovule culture - haploid production, triploid production, in-vitro pollination and fertilization, somaclonal variation, its genetic basis and application in crop improvement.

REFERENCES

1. M.K.Razdan. “Introduction to plant tissue culture” Science publishers, 3rd edition, 2005
2. H. S. Chawla, “Introduction to plant biotechnology” Science Publishers, 2002

Course Code	Course Title	L	T	P	C
GN2114	TRANSGENIC PLANTS: METHODS AND APPLICATIONS	3	0	0	3
	Total contact hours - 45				

PURPOSE	
To learn the methods involved in creation of transgenic crops and thus enhance productivity.	
INSTRUCTIONAL OBJECTIVES	
1.	To know the methods in mass propagation of plants through tissue culture.
2.	To learn various methods for production of transgenic plants.
3.	To know the legal concerns associated with cultivation of GM crops

UNIT I - METHODS OF PLANT TRANSFORMATION (12 hours)

Genetic modification by plant breeding versus genetic engineering, stable and transient transformation, Agrobacterium tumefaciens and Agrobacterium rhizogenes mediated transformation, microprojectile bombardment, agrolistics, in-planta transformation.

UNIT II -PRECISE GENOME MODIFICATION IN CROPS (10 hours)

Transformation by homologous recombination, gene editing nucleases, site specific recombination using zinc-finger nucleases, chloroplast transformation and maternal inheritance, gene containment.

UNIT III -VECTORS, PROMOTERS AND MARKERS USED IN TRANSGENIC PLANTS (9 hours)

Constitutive, tissue-specific and inducible promoters, deletion analysis, isolation of promoter, transcription initiation site determination, selectable and screenable markers, marker free transgenics.

UNIT IV - CHARACTERIZATION OF TRANSGENIC PLANTS

(6 hours)

Screening of transformants- copy number determination, expression of transgene at RNA and protein level, analysis of metabolites using biochemical methods, homozygosity of transformants in progeny, position effect, transgene silencing, field trials and risks, global status of GM crops, regulatory committee.

UNIT V - APPLICATIONS OF PLANT GENETIC ENGINEERING

(8 hours)

Over-expression or gene silencing for crop engineering, bioengineering crops for biofuel, production of recombinant proteins from plant cells (drugs, vaccines, antibodies), bioremediation, biotic stress (Bt cotton), abiotic stress (drought and salinity tolerance)

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REFERENCES

1. Ashwani Kumar and Sudhir K Sopory. "Recent advances in plant biotechnology and its applications" I.K. international publishers, 2008
2. Adrian Slater, Nigel W. Scott, Mark R. Fowler. "Plant biotechnology: the genetic manipulation of plants" Oxford University Press, 2008

Course Code	Course Title	L	T	P	C
GN2115	**CLASSICAL AND MOLECULAR PLANT BREEDING**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
PURPOSE					
To learn the principles and methods of conventional breeding and molecular breeding for crop improvement					
INSTRUCTIONAL OBJECTIVES					
1.	To learn genes and genotypes as individual and n populations				
2.	To learn the principles and methods of conventional plant breeding methods				
3.	To learn about molecular markers and their use in molecular breeding				

THEORY

UNIT I - INTRODUCTION (9 hours)

History of domestication and plant breeding. Current status of crop production and scope of crop improvement by plant breeding. Structure of reproductive organs, reproduction by selff pollination, cross pollination, apomixis and vegetative propagation. Phenotype, genotype, micro and macro environment, genotype environment interaction. Qualitative and quantitative traits.

UNIT II - POPULATION GENETICS (9 hours)

Genetic constitution of a population: Hardy-Weinberg equilibrium, factors affecting change in gene and genotypic frequency; Effects of mating systems, mutation, migration and selection. Continuous variation: Components of means: Additive and dominance components, non-allelic interactions, genotype x environmental interactions; Components of variance: Genetic and environmental components of variance.

UNIT III - PLANT BREEDING METHODS (9 hours)

Breeding methods in self-pollinated crops. Breeding methods in cross-pollinated crops.

Heterosis breeding- production of hybrids using male sterile systems. Mutation Breeding.

UNIT IV - MOLECULAR MARKERS AND MAPPING (9 hours)

Plant Genome-nuclear, chloroplast and mitochondrial genomes. Phenotypic versus molecular markers, different kinds of DNA markers for genome analysis (RFLP, RAPD, STS, SSR, AFLP, SNPs). Development of mapping population – RILs, NILs and DH lines- choice of mapping population. Molecular mapping.

UNIT V - MOLECULAR BREEDING (9 hours)

Marker-Assisted-Selection (MAS). Marker-Assisted Backcrossing (MABC). Case studies of MAS and MABC in rice.

REFERENCES

1. R.L. Agarwal, “Fundamentals of Plant Breeding and Hybrid Seed Production”, Oxford & IBH Book Publishing Co Pvt Ltd, New Delhi First Edition,1998.
2. A.W. Allard, “Principles of Plant Breeding”, Science Publishers, USA, Second Edition 1999.

3. Guimaraes et al, “Marker-Assisted Selection: Current status and future perspectives in crops, livestock, forestry and fish”. FAO Publication, 2007..
4. Collard et al “Rice Molecular Breeding Laboratories in the Genomics Era: Current Status and Future Considerations”. International J Plant Genomics. 2008:524847,(2008).

ELECTIVES- MODULE III – MICROBIAL GENETICS

Course Code	Course Title	L	T	P	C
GN2116	**MOLECULAR VIROLOGY**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				

PURPOSE

To enable the students to gain knowledge on mechanism of viral replication and its detection

INSTRUCTIONAL OBJECTIVES

1.	To gain knowledge on viral genome and its organization
2.	To get an understanding viral life cycle and interaction with plants
3.	To know the applications of virus in the field of genetic engineering

UNIT I - ORGANIZATION OF VIRAL GENOMES (9 hours)

Structure of the viral genome, viral genetics, virus mutants, genetic and non-genetic interactions between viruses, DNA content of viral genomes, positive strand RNA viruses, negative strand RNA viruses, segmented and multipartite viral genomes, reverse transcription and transposition.

UNIT II - VIRAL REPLICATION MECHANISMS (9 hours)

Host functions used by viruses – components for virus synthesis, energy, protein and DNA synthesis, synthesis of structural components of the cell wall, viral templates, replicase, sites of replication, examples of viral replication – Tobacco Mosaic Viruses, Cauliflower mosaic virus

UNIT III - VIRUS-PLANT INTERACTIONS (9 hours)

Inherent hose response – gene silencing, transcriptional and post transcriptional gene silencing, genes involved in post transcriptional gene silencing (PTGS), mechanism, systemic signaling, inductaion and maintenance, PTGS in virus infected plants, suppression of gene silencing.

UNIT IV - TECHNIQUES IN MOLECULAR VIROLOGY (9 hours)
Viral DNA extraction, purification and characterization, viral RNA transcription, viral transfection and determination of viral load, viral antigen detection, studies on viral mutants, polypeptides and assay of viral enzymes.

UNIT V - VIRUSES IN GENETIC ENGINEERING (9 hours)
Viruses as gene cloning vehicles, sources of control elements for transgenic plants, use of viruses for heterologous peptides and in functional genomics of plants, protection of plants from systemic diseases, - mild strain cross protection, satellite mediated protection, antiviral chemicals, viral vaccines – live attenuated, inactivated, virion subunit vaccines, live recombinant viral vaccines, mass production of viruses for vaccines.

REFERENCES

1. Roger Hull, Plant Virology, Elsevier Academic Press, 4th edition, 2004
2. Carter J, Saunders V Virology – Principles and Applications, John Wiley and Sons, (2007)
3. Brian W H Mahy, Kangro Hilar (1996) “Virology Methods” Manual, Academic Press.

Course Code	Course Title	L	T	P	C
GN2117	METAGENOMICS	3	0	0	3
	Total Contact Hours - 45				
PURPOSE					
To learn the fundamentals and applications of metagenomics in the field of genetic engineering					
INSTRUCTIONAL OBJECTIVES					
1.	To know about construction of metagenomic libraries				
2.	**To know about diversity analysis**				
3.	**To identify novel enzymes, antibiotics and other metabolites using metagenomic approaches**				

UNIT I - INTRODUCTION TO METAGENOMICS (9 hours)
Historical perspectives, microbial diversity analysis by rRNA analysis and culturing, development as metagenomics as a culture independent approach

UNIT II - CONSTRUCTION OF METAGENOMIC LIBRARIES (9 hours)

Choice of source material, methods for isolation of metagenomic DNA, assessment of purity and normalization, size fractionation, creation of metagenomic clones using plasmid libraries,BAC and YAC libraries, small and large insert libraries, shotgun libraries, plating and maintenance of recombinant E. coli metagenomic libraries.

UNIT III - SCREENING OF METAGENOMIC LIBRARIES (9 hours)

Sequence based approach, Functional metagenomics, , metagenomic screening using heterologous expression, clone identification methods – screens, seletion, functional anchors, metagenome screening using Substrate Induced Gene Expression Analysis (SIGEX)

UNIT IV - HUMAN MICROBIOMICS (9 hours)

Human microbiome project, host-pathogen interactions, human oral microbiome, human skin microbiome and skin infections.

UNIT V - APPLICATIONS OF METAGENOMICS (9 hours)

Metagenomics based screening for novel enzymes, antibiotics, anticancer drugs, microbial diversity analysis – metagenomic based survey of microbial communities, horizontal gene transfer, metagenomic analysis of plant – microbe interaction, application of metagenomics in bioremediation.

REFERENCES

1. Diana Marco, “Metagenomics: Theory, Methods and Applications”, Caister Academic Press, UK, 2010
2. Karen E. Nelsen, “Metagenomics of the Human Body”, Springer, 2011
3. Wu-Kuang Yeh, Hsiu-Chiung Yang and James R. Mcarthy, “Enzyme Technologies: Metagenomics, Evolution, Biocatalysis and Biosynthesis”, John Wiley and Sons, 2010
4. Jo Handelsman, “Metagenomics: Application of Genomics to Uncultured Microorganisms”, Microbiology and Molecular Biology Reviews, vol 68, pg 669-685, 2004.
5. Lorenz P, Eck J “Metagenomics and Industrial Applications”, Nature Reviews in Microbiology, vol 3, 510-516, 2005

Course Code	Course Title	L	T	P	C
GN2118	MOLECULAR PATHOLOGY OF INFECTIOUS DISEASE	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
To enable the students to acquire knowledge about the molecular pathology and diagnostic methods of infectious disease	
INSTRUCTIONAL OBJECTIVES	
1.	To know how molecular pathology developed from early stages.
2.	To understand the host defense mechanism against pathogens
3.	To understand the pathogenesis of some bacterial and viral disease
4.	To acquire the knowledge about virulence factors of pathogens.
5.	To know the diagnostic methods for the infectious disease

UNIT I - OVERVIEW OF INFECTIOUS DISEASE (9 hours)

Historical perspective of infectious diseases - early discoveries of microbial toxins, toxic assays, vaccines, antibiotics and birth of molecular genetics and modern molecular pathogenesis studies, Various pathogen types and modes of entry.

UNIT II - HOST RESPONSE TO INFECTION (9 hours)

Attributes & components of microbial pathogenesis, Host defense: skin, mucosa, cilia, secretions, physical movements, limitation of free iron, antimicrobial compounds, mechanism of killing by humoral and cellular defense mechanisms, complements, inflammation process, general disease symptoms, Pathogenic adaptations to overcome the above defenses

UNIT III - MOLECULAR PATHOGENESIS OF INFECTIOUS DISEASE (9 hours)

Molecular genetics and gene regulation in virulence of pathogens like Entamoeba histolytica, Mycobacterium tuberculosis, Vibrio Cholerae, E.coli, Plasmodium, HIV, Influenza virus.

UNIT IV- VIRULENCE FACTORS AND PATHOGENESIS (9 hours)

Virulence, virulence factors, Virulence assays: adherence, invasion, cytopathic, cytotoxic effects. Criteria & tests in identifying virulence factors, molecular characterization of virulence factors, signal transduction & host responses

UNIT V - DIAGNOSTIC APPROACHES FOR INFECTIOUS DISEAS

(9 hours)

Classical approaches based on serotyping. Modern diagnosis based on highly conserved virulence factors, immuno & DNA-based techniques. New therapeutic strategies based on recent findings on molecular pathogenesis of a variety of pathogens, Vaccines - DNA, subunit and cocktail vaccines.

REFERENCES

1. Iglewski B.H and Clark V.L "Molecular basis of Bacterial Pathogenesis", Academic Press, 1990.
2. Peter Williams, Julian Ketley & George Salmond, "Methods in Microbiology: Bacterial Pathogenesis, Vol. 27", Academic Press, 1998.
3. Recent reviews in Infect. Immun., Mol. “Microbiol, Biochem”. J., EMBO etc.