Candidates opting for this course are advised to go through the direction relating to the course “DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF MASTER OF SCIENCE, SEMESTER PATTERN (CHOICE BASED CREDIT SYSTEM) AND DEGREE OF MASTER OF SCIENCE AND TECHNOLOGY (APPLIED GEOLOGY). SEMESTER PATTERN, (CHOICE BASED CREDIT SYSTEM) (FACULTY OF SCIENCE & TECHNOLOGY)” which is available on R. T. M. Nagpur University website.

The direction will provide details on admission criteria, rules for ATKT, scheme of examination, absorption scheme for CBS students into CBCS pattern, elective papers, foundation course papers, subject centric papers, coding pattern, pattern of question papers, practicals, distribution of marks, seminars, project work, internal assessment, calculation of SGPA and CGPA, etc.

### Appendix-I

**Scheme of Teaching under choice based credit system for M.Sc. Program in Molecular Biology and Genetic Engineering**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Semester</th>
<th>Course Code/Paper</th>
<th>Title of the Paper</th>
<th>Course/ Paper</th>
<th>Teaching Scheme</th>
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1. In each semester student will have to give seminar on any topic relevant to the syllabus encompassing the recent trends and development in the field. The topic of the seminar will be decided at the beginning of the semester in consultation with the supervising teacher. Seminar will be open to all the teachers of the department invitees and students.

2. The students will have to carry out the research based project work in lieu of practical in the fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national/regional/private research institute for the duration of fourth semester. The student will be randomly allotted the priority number for the selection of the supervisor in the third semester. The student in consultation with supervisor will finalize the topic of the project work at the third semester.

3. The course can be taught by person having post graduate qualification in relevant/ equivalent subjects/ or having teaching/ research experience in that particular field.
## Course structure of M.Sc. syllabus to be implemented from 2017-18

<table>
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| **Semester II** |                                                                                     | **25 Credits**   |
| MBGE V 2T1      | BIOPHYSICAL ANALYTICAL TECHNIQUES                                                    | 4                |
| MBGE VI 2T2     | ENZYME TECHNOLOGY & IMMUNOLOGY                                                       | 4                |
| MBGE VII 2T3    | IPR, BIOSAFETY, BIOETHICS AND ENTERPRENEURSHIP                                       | 4                |
| MBGE VIII 2T4   | BIOINFORMATICS AND DATA MINING & LAB. MANAGEMENT & SAFETY                            | 4                |
| MBGE III 2P1    | PRACTICAL III – V & VI                                                               | 4                |
| MBGE IV 2P2     | PRACTICAL IV – VII & VIII                                                            | 4                |
| 2S1             | SEMINAR                                                                             | 1                |

| **Semester III**|                                                                                     | **25 Credits**   |
| MBGE IX 3T1     | INDUSTRIAL APPLICATIONS OF GENETIC ENGINEERING                                       | 4                |
| MBGE X 3T2      | RECOMBINANT DNA TECHNOLOGY I                                                         | 4                |
| MBGE XI 3T3     | ELECTIVE I                                                                           | 4                |
| MBGE XII 3T4    | SUBJECT CENTRIC I / FOUNDATION COURSE I                                             | 4                |
| MBGE V 3P1      | PRACTICAL V: COURSE IX – X                                                           | 4                |
| MBGE VI 3P2     | PRACTICAL VI: COURSE XI                                                             | 4                |
| 3S1             | SEMINAR                                                                             | 1                |

| **Semester IV** |                                                                                     | **25 Credits**   |
| MBGE XIII 4T1   | PLANT & ANIMAL GENETIC ENGINEERING                                                   | 4                |
| MBGE XIV 4T2    | RECOMBINANT DNA TECHNOLOGY II                                                        | 4                |
| MBGE XV 4T3     | ELECTIVE II                                                                          | 4                |
| MBGE XVI 4T4    | SUBJECT CENTRIC II / FOUNDATION COURSE II                                           | 4                |
| MBGE VII 4P1    | PRACTICAL VII: COURSE XIII – XV                                                     | 4                |
| MBGE VIII 4P2   | PROJECT                                                                              | 4                |
| 4S1             | SEMINAR                                                                             | 1                |

**ELECTIVE PAPERS – 1)** PLANT GENETIC ENGINEERING I & II  
2) MOLECULAR DIAGNOSTICS FOR GENETIC DISORDERS/DISEASES I & II  
3) BIOINFORMATICS I & II

**Foundation course**: For other than Mol. Bio. & Gen. Eng students  
PAPER I: MOLECULAR BIOLOGY  
Paper II: RECOMBINANT DNA TECHNOLOGY and PLANT GENETIC ENGINEERING
M.Sc. Molecular Biology and Genetic Engineering

Semester I

Course code/name:
MBGE I (1T1) : CELL BIOLOGY (PROKARYOTES AND EUKARYOTES)
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1: 15L

Ultra-structure of prokaryotic and eukaryotic (plant & animal) cells
Plasma membrane, cell wall their structural organization.
Cellular organelles – Mitochondria, chloroplast; Nucleus, Golgi apparatus.
other organelles and their organization,
Transport of nutrients, ions and macromolecules across membranes.

Module 2: 15L

Cell cycle- Different phases of cell cycle, Controls and Check points,
cyclins and cdks – types and their role. Molecular, events and model
systems, Apoptosis, Cytoskeleton and Cell motility
Cell communication: General principles of signaling – endocrine, exocrine
& synaptic signaling, surface and intracellular receptors, G proteins and
generation of secondary messenger, mode of action of cAMP and ca++ calmodulin,
Target cell adaptation, cellular responses to environmental signals in plants and
animals - mechanisms of signal transduction

Module 3: 15L

General characters of microorganisms: Historical developments in Microbial
Biotechnology, The concept of Microbial origin of Fermentation, Microscopy
and microscopic observation of Microorganisms, Structure and general
characters of Bacteria, Archaea, Fungi and Algae, Classification of Bacteria,
Fungi and Algae

Module 4: 15L

Viruses: General characters of viruses, Morphology and structure of viruses,
chemical composition of viruses, Nomenclature and classification of viruses
(8th report of ICTV), Genetic classification of viruses, Life cycle of T4 phage,
Lambda (λ) phage, Retroviruses (HIV), TMV, and SV40, Methods of cultivation
of viruses, Importance of viruses in biotechnology.
Practicals:

1. Morphological study of mitotic & meiotic chromosomes
2. Cell fractionation
3. Sterilization methods (Autoclaving, Hot air oven, radiation and filtration)
4. Preparation of routine microbiological media
5. Microscopic observation, Staining and identification of bacteria, fungi and algae
6. Culturing & preservation of microorganisms: Tube culture (slant/broth), plate culture, flask culture & preservation
7. Isolation of bacteria, fungi, algae and bacteriophages
8. Measurement of microbial growth (Viable count and turbidometry)
9. Study for bacterial growth curve

Books Recommended:

10. Microbiology, Tortora, Funke and Chase, Benzamin & Cummings
Course code/name: MBGE II (1T2): BASIC BIOCHEMISTRY
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1: 15L

Carbohydrates – Brief introduction (Structure & classification of simple sugars and Polysaccharides)
Carbohydrate Metabolism Embden, Meyerhoff and Parnass EMP)
Pathway & its regulation, Krebs cycle and its regulation, Krebs Kornberg Cycle,
glycogenolysis, glycogenesis, gluconeogenesis Pentose Phosphate pathway and its regulation, Glucuronate-Xylulose pathway, Oxidative phosphorylation.

Module 2: 15L

Amino acids and Proteins – classification, chemical reactions and physical properties, criteria of homogeneity, end group analysis, 3D structure of proteins, hierarchy in structure, 1ο, 2ο, 3ο, quaternary structure, domain structure, Structure of the Peptide bond, Ramachandran plot, Biosynthesis and degradation of individual amino acids, Urea Cycle.

Module 3: 15L

Lipids – classification, physicochemical properties, structure and functions
Lipid Metabolism: Beta Oxidation of Fatty acids, fatty acid biosynthesis
Biosynthesis of simple fat, phospholipids, cholesterol, sulfolipids and their possible regulation.

Module 4: 15L

Structure and functions of Heme and chlorophyll and antibiotics (penicillin, streptomycin, chloromphenical)
Hormones: Types (Plant and animal), chemistry, physiological role and Regulation. Endocrinopathies
Vitamins – Types (water and fat soluble), chemistry, sources, RDA, physiological role, deficiency manifestations.
Practicals:

1. Quantitative determination of proteins by Biuret and Lowry’s methods or Ninhydrin test
2. Quantitative Estimation of lipids & Fatty acids profiling in various plant materials by GC
3. Determination of acid number, iodine value in fats.
4. Study of activity of decarboxylase enzyme
5. Determination of sugars by anthrone method
6. Isolation of plant pigments

Books Recommended:

5. Biochemistry-Rawn, D., Pamina publications, 2004
Module 1: 15L

Gene: gene concept, unit of function, replication, recombination and mutation
Fine structure of gene: bar locus, complex loci, rII locus and complementation analysis
Gene function: one gene/one enzyme hypothesis, pathways of gene action.
Genome organization: Genome organization in prokaryotes and eukaryotes
special features of eukaryotic gene structure and organization, genome organization
in mitochondria and chloroplast.

Module 2: 15L

DNA content and C-value paradox, methods to measure DNA content variation
Various types of DNA sequences (simple sequences, repetitive sequences, nonsense
sequences, tandem gene clusters, satellites)
DNA Damage and repair: Spontaneous and Induced mutations – Physical and Chemical
mutagenesis, Molecular mechanisms of mutagenesis – Transition, Transversion, Frame Shift,
mis-sense and non-sense mutations, Photo-reactivation, Excision Repair, Mismatch
Repair, Post-replication Repair, SOS Repair

Module 3: 15L

Recombination in bacteria and viruses: Transformation: Competence factors,
mechanism of transformation, mapping genes by transformation,
Conjugation: Structure of F plasmid, Mechanism of transfer of F plasmid, Hfr,
mechanism of integration of F plasmid into bacterial chromosome, circularization
of chromosome, Conjugation mapping – different methods.
Transduction & Gene mapping.
Genome Rearrangements and Recombination: Complete and Segmental
Duplication of Genomes, Insertion, Deletion and Translocation of Sequences,
Process of Rearrangements, Homologous Recombination – rec Pathways, Site
specific Recombination, Non-homologous End Joining, Transposon and Repeats
mediated Rearrangements, Molecular mechanisms of Gene Conversion.

Module 4: 15L

Genetics of Caenorhabditis alligans, Yeast, Drosophila, and Human:
Caenorhabditis alligans gene regulation and silencing
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,
generegulation


Practicals:
1. Isolation, and study of polytene chromosome in Drosophila
2. Study of structure chromosomal rearrangements
3. Effect of mutagens on physiology and genetic material of suitable organism
4. Bacterial conjugation
5. Bacterial transduction
6. Bacterial transposons

Recommended books:
Course code/name: MBGE IV (1T4) : MOLECULAR BIOLOGY II
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1: 15L

Biosynthesis of purines and pyrimidine nucleotides from ribose including regulation, salvage pathways
Structure, types and function of nucleic acids (DNA & RNA)
DNA Replication: Prokaryotic and eukaryotic DNA replication mechanism, enzymes and accessory proteins involved in DNA replication.

Module 2: 15L

Protein Synthesis: Prokaryotic transcription, eukaryotic transcription, RNA polymerases, General and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, 5’ Cap formation, Transcription termination, 3’end processing and polyadenylation, nuclear export of mRNA, mRNA stability
RNA splicing: Nuclear splicing, spliceosome and small nuclear RNAs, group I and group II introns, Cis- and Trans- splicing reactions, tRNA splicing, alternate splicing.
Genetic Code, Prokaryotic and eukaryotic translation - Synthesis of aminoacyl tRNA, aminoacyl synthetases, Mechanism of initiation, elongation and termination,
Regulation of translation, co-and post-translational modifications of proteins, mobility shift assay, Dipeptide assay, Tripeptide assay, In vitro translation.

Module 3: 15L

Regulation of gene expression: Induction and repression, operon theory, lac operon, trp operon, ara operon, attenuation, positive and negative control, catabolite repression, regulation of transcription by cAMP and CRP, and guanosine tetraphosphate, Run off transcription. Britten-Davidson and Mated models of gene regulation, regulation of gene expression in eukaryotes.

Module 4: 15L

RNA interference: RNA silencing in cytoplasm and genome level, ds RNA mediated RNA interference (Si RNA and micro RNA), RNAi pathways (si RNA and mi RNA pathway), Functions and RNA interference (Protection against viral infections, securing genome stability, repression of protein synthesis and regulation, chromatin condensation and transcriptional suppression, RNAi as an experimental tool for suppressing gene expression, potential therapeutic use of RNAi, Molecular mechanism of antisense molecules.
Biochemistry of ribozyme; hammer – head, hairpin and other ribozymes, strategies for designing ribozymes, applications of antisense and ribozyme technologies.
Interacelullar protein transport: synthesis of secretory and membrane proteins, Import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis, Protein targeting and protein localization signals, role of golgi
Practicals:

1. Study of expression of inducible genes
2. Regulation of gene expression
3. Isolation of total cellular RNA from suitable organisms (yeast, plant, animal cells)
4. Isolation of total m RNA from suitable organisms

Recommended books:


Practicals (10 Credits):
MBGE I (P) : Practical I: (5 credits) Based on Course : I & II
MBGE II (P): Practical II: (5 credits) Based on Course : III & IV
Semester II

Course code/name:
MBGE V (2T1): BIOPHYSICAL ANALYTICAL TECHNIQUES
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module I: 15L
Centrifugation: Differential centrifugation, Density gradient centrifugation, Ultracentrifugation.
Characterization of macromolecules using X-ray diffraction analysis
Mass spectrometry: Theory, Instrumentation and applications
Various hyphenated techniques: Theory and applications of LC-MS, GC-MS, HPTLC-MS, etc.

Module II: 15L
Various types of Chromatographic Techniques:
TLC, HPTLC, GC and Column chromatography (Partition, Adsorption, Ion-exchange chromatography,
Gel filtration chromatography, affinity chromatography, reverse phase chromatography, HPLC)
Electrophoresis:
Principles, Agarose, Starch, PAGE including SDS-PAGE, Pulsed Field Gel Electrophoresis,
Isoelectric focusing, Isotachophoresis, gel-documentation

Module III: 15L
Spectrophotometric Techniques:
Fundamentals of Absorption and Emission spectrophotometric techniques
Theory, instrumentation & application of visible, UV, IR, AAS, NMR, ESR, CD, ORD, fluorescence
and Raman spectrophotometric techniques.

Module IV: 15L
Microscopy, phase contrast, fluorescence, Electron, confocal, scanning
tunneling and polarization microscopy; Cell sorter and its applications
Radio isotope technique: Radioactive decay constant, half life of an isotope,
Detection and measurement of radioactivity, Geiger Muller counters,
scintillation counting, auto radiography and RIA, Application of isotopes
in biological studies.
Practicals:

1. Study of Laboratory Instruments:
   - Electrophoresis unit, Autoclave, Water bath, Hot air oven, Laminar air flow, Light microscope, Haemocytometer and cell number determination, pH meter, Centrifuge, Spectrophotometer, HPCL / GC, balance, Pipettes
2. Preparation of various Buffers and to check its pH, preparation of solution of given Morality, Normality and its Standardization by titration methods.
3. Separation and Identification of Biomolecules by TLC, gel filtration, ion exchange, affinity chromatography
4. Separation and identification of biochemical compounds by HPLC
5. Separation of biomolecules by centrifugation
6. Study of cell viability by fluorescence microscope
7. Separation of DNA and Proteins by Electrophoresis
8. Quantification of biocompounds by spectrophotometer
9. Gel documentation of DNA, RNA and proteins

RECOMMENDED BOOKS:

Course code/name:
MBGE VI (2T2) : Enzyme technology and Immunology
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1: 15L

Enzymes: classification and nomenclature, isolation purification of enzymes, localization of enzymes, concept of apo-enzyme and holo-enzyme, isoenzymes in health and diseases. Relevance of structure function relationship of enzymes, Determination of active site of an enzyme, Mechanism of enzyme action through covalent catalysis, acid-base catalysis and or proximity induced catalysis.
Kinetics: Michaelis-Menten equation, Lineweaver-Burke plot, Eadie-Hofstee plot, Competitive, uncompetitive and non-competitive inhibition

Module 2: 15L

Concept of ribozyme and catalytic antibodies in enzyme technology. Multienzyme complex and its role in metabolic regulation (Fatty acid synthase complex and Pyruvate dehydrogenase complex), Allosteric enzymes as a regulatory tool in metabolism with its general features and kinetics- ATCase
Mechanism of catalysis by Lysozyme, Ribonuclease and Carboxypeptidase

Module 3: 15L

Introduction: Immunity, immune response, Immune system, Cells and organs of Immune system
Innate immunity, Antigens- Factors affecting antigenicity, Antibodies-Structure and isotypes
Antigen presentation by MHC class I and II, Humoral and cell mediated immunity-TCR, BCR and signal transduction, Complement system
Antigen antibody reactions: Kinetics, specificity, Immunochemical techniques- Precipitation, agglutination, Complement fixation, Immunodiffusion, RIA, ELISA

Module 4: 15L

Immunological tolerance, Autoimmunity, Hypersensitivity and Immune responses to pathogens (Virus, bacteria, fungi, parasites), Transplantation and Tumor immunology, Vaccinology, Antibody therapy, Monoclonal Antibodies and Superantigens
Practicals:
1. Study of Factors affecting Enzyme activity: Cofactors, inhibitors, substrate concentration, temperature and pH
2. Study of Isocitrate dehydrogenase in yeast- An allosteric enzyme
3. Separation of isoenzymes by native PAGE.
4. Electrophoresis of serum proteins by SDS-PAGE
5. Methods for immobilization of enzymes
6. Sandwich Enzyme-Linked Immuno-sorbent Assay (ELISA) to test antigen concentration
7. Radial immunodiffusion Assay for finding the concentration of Antigen and Ouchterlony Double Diffusion assay to compare the two antigens against an antibody.
8. Latex agglutination test for detection of antigen and antibody
9. Study of Immuno-histochemistry test for localizing antigen
10. Collection of human blood, separation of mononuclear cells and counting of viable cells

Recommended Books for Enzymology:

Recommended Books for Immunology:
8. Immunology - Klaus D. Elgert , Wiley-Liss. NY.
9. Text Book on Principles of Bacteriology, Virology and Immunology, IX Edn. (5 volumes)
10. Topley and Wilson’s, Edward Arnold, London. The Experimental Foundations of Modern Immunology - Clark, V.R., John Willey and Sons, Incl.
Course code/name:  
MBGE VII (2T3) : IPR, BIOSAFETY, BIOETHICS AND ENTERPRENEURSHIP  
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1:  
Intellectual property rights (IPR), sovereignty rights, CBD, bioethics and patenting  
General agreement on trade and tariffs Indian sui-generis system for animal variety  
and farmer’s rights protection act, PVFRA , WTO with reference to biotechnological  
affairs, TRIPs.  
General Introduction: Patent claims, the legal decision – making process, ownership  
of tangible and intellectual property, Patent litigation.  
Basic Requirements of Patentability: Patentable subject matter, novelty and the public  
domain, non obviousness.  
Special issues in Biotechnology Patents: Disclosure requirements, Collaborative  
research, Competitive research.  
Plant biotechnology Indian patents and Foreign patents, Plant variety protection act,  
The strategy of protecting plants.  
Recent Developments in Patent System and Patentability of biotechnological  
inventions. IPR issues in Indian Context Role of patent in pharmaceutical industry, computer  
related innovations. Case studies Rice, Turmeric, Margo, etc. and challenges ahead.

Module 2:  
Entrepreneurship  
Concept, definition, structure and theories of entrepreneurship  
Types of start-ups  
Types of entrepreneurship, environment, process of entrepreneurial development,  
Entrepreneurial culture, entrepreneurial leadership,  
Product planning and development  
Project management  
Search for business idea  
Concept of projects  
Project identification, formulation  
Design and network analysis  
Project report and project appraisal

Module 3:  
Ethical Issues: Introduction – causes of unethical acts, ignorance of laws,  
codes, policies and Procedures, recognition, friendship, personal gains  
Professional ethics – professional conduct  
Ethical decision making, ethical dilemmas  
Teaching ethical values to scientists, good laboratory practices, good manufacturing  
practices, laboratory acModuleation  
Bioethics & Society (Indian context): Ethical issues on New Genetics – Human  
Genome Project – Gene therapy – Genetic screening – Experimentation with human  
subjects -National Practice of health care – Public & Private medical practice –  
National resource allocations.
Module 4:

Biosafety in the laboratory institution: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/institution

Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroad

Biotechnology and food safety: The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance.

Ecological safety assessment of recombinant organisms and transgenic crops, case studies of relevance (Eg. Bt cotton).

Biosafety assessment of biotech pharmaceutical products such as drugs/vaccines etc.

International dimensions in biosafety: Catagena protocol on biosafety, bioterrorism and convention on biological weapons

Practicals:

Report submission on Biosafety assessments, transgenic crop, Bioethics & Society, Preparation of patent application, Seeking permission to work on GM crops, IGMORIS, application for strip trails, application for BRL I and II (case studies).

Recommended Books:

- Intellectual Property Rights - Brigitte Anderson, Edward Elgar Publishing
- WIPO Intellectual Property Handbook
- Intellectual Property Rights - William Rodelph Cornish, David Clewelyn
- Entrepreneurship: New Venture Creation - David H. Holt
- Patterns of Entrepreneurship - Jack M. Kaplan
- Entrepreneurship and Small Business Management: C. B. Gupta, S. S. Khanka, Sultan Chand

Websites:

Course code/name:  
MBGE VIII (2T4) : BIOINFORMATICS AND DATA MINING &  
LABORATORY MANAGEMENT AND SAFETY  
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1:  
Introduction to Bioinformatics, Importance of the subject in handling biological data.  
Bioinformatics data – nucleic acid sequence, protein sequence, protein structure,  
genomic, proteomic and metabolomic information  
Bioinformatics databases – types (Nucleic acid sequence databases: GenBank,  
EMBL, DDBJ; Protein databases: UniProt, SWISS-PROT, TrEMBL, PIR_PSD ;  
Genome Databases (NCBI, EBI, TIGR, SANGER ), file formats (genbank, fasta,  
msf, nbrfpir etc.), access tools with examples  
Bioinformatics tools and Resources – free online tools, downloadable free tools,  
software packages, internet, Bioinformatics books and Journals, Bioinformatics  
web portals

Module 2:  
Basic concepts of sequence, similarity, identity and homology, definitions of  
homologues, orthologues, paralogues,  
Sequence analysis methods in bioinformatics,  
Dot-matrix comparison (Pairwise alignment algorithms – Needleman and Wunch algorithm,  
Smith Watermann algorithm, Scoring matrices: basic concept of a scoring matrix,  
Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series)  
Basics of sequence alignment - match, mismatch, gaps, scoring alignments,  
gap penalty, protein vs DNA alignment  
Multiple sequence alignment algorithms – progressive alignment algorithms,  
heuristic algorithms - Blast algorithm, FASTA algorithm,  
Molecular Phylogenetics,  
Multiple sequence alignment based databases searching: Consensus sequence,  
patterns, profiles.

Module 3:  
Standards for analysis & Quality management  
Basic standards, Need of standards in analytical sciences  
Analytical standards- Reference materials/controls (positive & negative), High purity  
substances, certified reference material  
Working or secondary standards, matrix effect in standards  
Biological standards, Biochemical standards, Microbial cell lines and standards  
Quality Management - Quality system, Inspection and testing, Handling, Storage,  
Packaging, Preservation of the material, Internal quality audits, Quality assurance.  
Laboratory AcModuleation, AcModuleation Boards, NABL guidelines for AcModuleation in India  
Proficiency testing system, Internal quality control, Inter and intra laboratory testing programmes, Advantages of  
AcModuleation.
Module 4:
Laboratory Management & Safety :
Administration of Laboratories, Laboratory design, Security measures, Laboratory Information management system (LIMS)
Laboratory safety – Safety policies
Operation Hazardous compound - chemicals, solvents, poisons, isotopes, explosives and Biological strains (Bacterial, fungal etc)
Storage of hazardous material and disposal of biological and radioisotope wastes

Practicals:
1. Training on usage of various bioinformatics tools (online), software packages, web portals
2. Online searching of various databases (nucleic acids, proteins, organisms) using diff.
   Bioinformatics tools (FASTA, BLAST)
3. To find the sequences of a given protein in SWISS-Prot, Uni-Prot
4. To search biochemical pathway involved for a given trait.
5. To work out the sequence from given autoradiogram and to identify it from Gene Bank by BLAST method.
6. To generate Pair-wise and multiple sequence alignment of a given organisms
7. To generate phylogenetic tree using given sequences.
8. To predict a protein from given sequence by using online tools from NCBI.
9. To design PCR primers for isolation of given gene and to clone it in the given vector.
10. To generate the map of given plasmid and find the Reporter gene.
11. To predict N-Glycosylation site in the given protein sequence.
12. Translate the given gene sequence.
13. To find out ORF in the given gene sequence.
14. To find out the promoter in the given sequence.
15. Compositional analysis of DNA – GC/AT content - codon usage - codon bias

Recommended Books:
2. Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter,
16. Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, internet, Bioinformatics books and Journals, Bioinformatics web-portals

www.wormbook.org
www.ceolas.org/VL/mo/

**Practicals (10 credits)**
MBGE III (2P1) Practical III – V & VI (5 Credits)
MBGR IV (2P2) Practical IV – VII & VIII (5 Credits)
SEMESTER III

Course code/name:  
MBGE IX (3T1) : Industrial Applications of Genetic Engineering  
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1:  
Introduction to Bioprocess Engineering, Bioreactors. Types of fermentation processes:  
Analysis of batch, Fed-batch and continuous bioreactions, stability of microbial reactors,  
analysis of mixed microbial populations, specialized bioreactors (pulsed, fluidized,  
photobioreactors etc.), Measurement and control of bioprocess parameters.  
Downstream Processing: Introduction, Removal of microbial cells and solid matter,  
foam reparation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid  
eXtraction, chromatography, Membrane process, Drying and Crystallization.

Module 2:  
Industrial Production of Chemicals: Alcohol (ethanol), Acids (citric, acetic and gluconic),  
solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline),  
Aminoacids (lysine, glutamic acid), Single Cell Protein.  
Whole cell Immobilization and their Industrial Applications.  
Microbial applications for mineral beneficiation (bioleaching) and oil recovery.

Module 3:  
Environment: Basic concepts and global issues.  
Environmental Pollution: its types, measurement and control measures.  
Physical, chemical, biological and advance treatment processes of waste water treatment.  
Treatment schemes for waste water of pulp & paper mill, dairy, distillery, and tannery.  
Global Environmental Problems: Ozone depletion, UV-B, green-house effect and acid rain,  
their impact and biotechnological approaches for management.

Module 4:  
Environmental Biotechnology, Environment-friendly technologies- biobleaching.  
Bioremediation-microbial, phycoremediation, mycoremediation, phytoremediation,  
its mechanism, techniques & applications for reclamation of contaminated soils,  
Waste land, water bodies and industrial effluents, advantages, disadvantages of  
bio remediation technology.  
Solid waste management (landfills, vermiculture, biotechnologies for plastic & e-waste management).  
Biopesticides and integrated pest management (IPM).

Practicals:
1. Isolation of Industrially important microorganisms from microbial processes  
2. Development of laboratory scale bioreactors: know how  
3. Recovery of product from fermentation broth and optimization of parameters  
4. Extraction of protein from a crude bioprocess homogenate using Aqueous Two Phase System (ATPS)  
5. Comparative studies of ethanol production using different substrates  
6. Production of microbial biofertilizers and biopesticides  
7. Determination of Biology Oxygen demand (BOD) of sewage sample  
8. Determination of Chemical Oxygen demand (COD) of sewage sample  
9. Testing for microbiological quality of potable water (Coli form test)
10. Microbial degradation of organic matter
11. Testing for microbial biodegradation of pesticides

**Recommended Books:**

13. E.M.T. EL` Mansi & C.F.A. Bryce Fermentation Technology and Biotechnology
15. Environmental Microbiology. Grant, WD and Long PE. Publ: Blakie, Glasgow
17. Microbial Ecology: Principles, Methods and Applications by Lavin, Seidler, Rogul
18. Laboratory Experiments in Microbiology by Gopal Reddy et al
20. Air Pollution Vol I by A.C. Stern
21. Environmental management by Biswarup Muhkerjee V. Publication House
22. Pollution Biology: Hynes
23. Environmental Biology by Biswarup Muhkerjee Tata Mcgraw Hill
24. Modern Concepts of Ecology by H.D.Kumar
Course code/name:

MBGE X (3T2): RECOMBINANT DNA TECHNOLOGY I
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1:

Scope of Recombinant DNA Technology, Milestones in Genetic Engineering
Isolation, purification, and quantification of DNA and RNA
Preparation of total cellular DNA from animal & plant, preparation of plasmid
DNA, bacteriophage DNA, separation and quantization of DNA by Gel electrophoresis.
Total cellular RNA, cytoplasmic and nuclear RNA, poly (A+) RNA, detection &
quantitation and gel electrophoresis.
Methods of gene transfer techniques in plants and animals (Agrobacterium
mediated, electrophoration and particle gun, liposome, PEG).

Module 2:

Cutting, joining and modifying and amplifying DNA, Restriction endonucleases,
Ligases, Alkaline phosphatase, polymerases. Double digest modification of restriction
fragment ends. Other ways of joining DNA.
Amplification of DNA-PCR and cell based DNA cloning, importance of cloning,
PCR: Basic features, optimization of PCR parameters, types of PCR and
applications, principles of cell based DNA cloning, cloning system for producing
single stranded and mutagenized DNA.

Module 3:

Gene Cloning Vectors: Plasmids, bacteriophages, phagemids, cosmids, Artificial
chromosomes.
Alternative Strategies of Gene Cloning: Cloning interacting genes-Two-and three hybrid
systems, cloning differentially expressed genes, Nucleic acid microarray arrays.
cDNA Synthesis and Cloning mRNA enrichment, reverse transcription, DNA primers, Linkers,
adaptors and their chemical synthesis, Library construction and screening, construction and
screening of genomic libraries.

Module 4:

Nucleic acid hybridization: Principles and applications, preparation of probes,
principles of nucleic acid hybridization, nucleic acid hybridization assays and micro-assays.
Tools for analyzing gene expression: Reporter genes, Analysis of gene regulation,
purification & detection tags, analysis at the level of gene transcription –
Northern blot, in situ hybridisation, RNAse protection assay, RT-PCR analysis at the level of translation
Western blot, in situ analysis, ELISA, protein gel electrophoresis, antibody production.
Practicals:
1. Isolation of DNA from suitable microorganism/ higher organism
2. DNA amplification by PCR
3. Restriction digestion of genomic or lambda DNA and size determination of the fragments
4. Determination of insert size by R.E analysis
5. Preparation of competent cells, transformation of E.coli and screening of transformants
6. (Blue / white screening)
7. Analysis of recombinant clone
8. Ligation of vector and insect DNA, and checking of LM
9. Western Blotting

Recommended Books:
1) RNA methodologies-A laboratory guide for isolation & characterization, 3rd Edn., Farell, R. Elsevier 2005
3) Molecular Biology of the Cell, 5th edn, Alberts 2008, Grandland science
4) Cells-Levin, 1st Ed. Jones & Bartlett Publisher 2006
8) Cell & Molecular & William & Wilkins 2006
ELECTIVE PAPER I
Course code/name: MBGE XI (3T3): PLANT GENETIC ENGINEERING
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

MODULE I
Plant breeding technique and domestication of plant
Historical account of plant tissue culture
Technique of plant tissue culture
Shoot tip and meristem cell culture-isolation and culture of plant stem cell for clonal
propagation and disease free plant propagules multiple shoot induction.
Somatic Embryogenesis- direct and indirect role of growth regulators , explants types,
genotype and cultural condition and somaclonal variation.

MODULE II
Suspension culture and production of plant secondary metabolites
Production of haploid plants and homozygous lines and its signification in crop improvement
Protoplast isolation ,culture and fusion technique – selection and regeneration of hybrid
plants, symmetric and asymmetric hybrids cybrids.embryo rescue technique. Synthetic seed
technology.

MODULE III
Plant transformation technology-
Basis of tumour formation, mechanism of DNA transfer. feature of Ti and Ri plasmid and
their uses as vector, role of virulence gene , binary vectors markers. Use of reporter of gene
35 S and other promoter. methods of nuclear transformation -direct and indirect.
Application of plant transformation for productivity and performance. Development of
transgenic plant for herbicide,insect resistance and disease resistance
Male sterility-Bar and Barnes system.

MODULES IV
Metabolic engineering and industrial production : plant secondary metabolites,
control mechanism and manipulation of phenolpropanoid pathway, shikimate pathway,
alcaloids, industrial enzyme, biodegradable plastics,polyhydroxybutyrate, therapeutic
protein, lysosomal enzymes, antibodies ,edible vaccines ,puriﬁcation strategies oleosin
partitioning technology.
Molecular marker aided breeding : RFLP maps, linkage analysis , RAPD markers STS
microsatellite ,SCAR (sequence characterized amplified region), SSCP(single stranded
conformational polymorphism)AFLP, QTL, map based cloning, molecular marker assisted
selection.

PRACTICALS:
1. Media Preparation
2. Meristem and axillary bud culture
3. Organogenesis & Somatic Embryogenesis
4. Embryo Rescue Technique
5. Anther /Pollen culture technique
6. Morphology and cytology of callus
7. Isolation of DNA
8. Estimation of plant DNA by agarose gel electrophoresis.
9. Spectrophotometric estimation of DNA.
10. Cell suspension culture technique.

FOUNDATION COURSE I:

Practicals: (Total 10 Credits)

MBGE V (P): Practical V (5 Credits): course IX - X
MBGE VI (P): Practical VI (5 credits) : course XI
Course code/name: Elective Paper I:
MBGE X I (3T3) : MOLECULAR DIAGNOSTICS METHODS
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

MODULE 1:

Introduction to Molecular diagnostics and its significance in post genomic era in health care industry; Gene and signal amplification techniques for diagnostics; Molecular diagnosis of pathogen (Bacteria, fungi, virus and protozoas) mediated diseases; immune disorders; cancer and their role in cancer management and cancer susceptibility; Molecular tools in genetic counseling; pre-symptomatic, prenatal tests and new born screening; applications in Health care and forensics; concerns in Molecular diagnostics and genetic testing; regulatory & ethical issues.

MODULE 2:

Principles and methods of isolation and purification of nucleic acids(DNA & RNA) from microbes, animal, human etc. Molecular cloning, labeling of nucleic acids, hybridization.
Electrophoretic methods for mutation detection: SSCP, hetero-duplex analysis, DGGE and TRFLP, Chemical Cleavage of mismatched nucleotides, Ribonuclease cleavage of mismatched DNA, RNA duplexes,
Preparation of RNA sample containing miRNA, miRNA detection methods SNP detection methods and applications.

MODULE 3:

Nucleic acid amplification methods: Types of PCR, Reverse transcriptase PCR, Real time PCR, Inverse PCR, Multiplex PCR, Nested PCR, Labelling PCR, Allele specific PCR, Quantitative fluorescent PCR, Alu PCR, Hot-start, In situ PCR, Long PCR, PCR-ELISA, Arbitrarily primed PCR, Triplet primed PCR, Isothermal amplification (TMA, NASBA, SDA) multiple thermal amplification; Linked Linear amplification, Ligation assay, Primer extension, applications of PCR, PCR based genetic analysis.

MODULE 4:

DNA sequencing methods – Principles and various DNA sequencing methods; Next – generation sequencing – Massively parallel sequencing platforms, Titanium, Illumina Genome analyzer II SOLID 3 system, paired End sequencing; Pyrosequencing-microarrays; DNA bar coding data analysis and storage.
Practicals:
Isolation of genomic DNA from microbe, animal and human
Isolation of Plasmid DNA
Quality and Quantitative analysis of DNA by UV spectrophotometer, agarose gel electrophoresis etc.
Isolation of RNA from prokaryote (E.coli) and eukaryote (C. elegans).
PCR amplification of Genomic DNA, plasmid DNA
Real time PCR demo
Automated DNA sequencing data observations and analysis.

Recommended Books:
John M Walker & Ralph Rapley Hand book of Molecular Biomethods
Michal Janitz Next Generation Genome sequencing: Towards personalized medicine
Tom Strachan, Andrew Read. Human Molecular Genetics (Taylor and Francis) 2010 ISBN: 9780815341499
Module 1
Basic Mathematics

Limits: Constants, Types of constants, Variables, Types of Variables, Function, Types of function, Right hand and left hand limits, working rule for finding out the limit, problems based on limits. Continuity: Define, point out discontinuity, Method of finding the continuity, Continuity from right and from left, Problem based on continuity. Differentiability: Basic concept of the derivatives of function, Definition of the derivative of function, right hand and left hand derivatives, Condition for differentiability of a function, Problem based on differentiability. The binomial theorem: Define, Binomial theorem for a positive integral index, Binomial Expansion, Finding middle term, general term, Binomial theorem for any index. Differentiation and Integration: Introduction, Basic concepts and problems related to differentiation.

Module 2
Basic Biostatics:


Module 3
INTRODUCTION TO COMPUTER APPLICATION, Programming and data base management

Computer organization; Softwar - System software and Application software. Networking fundamentals, types of networking, network topology; File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP). Internet basics; Hyper Text Markup Language (HTML). Web designing; Web servers. Techniques of problem solving, Algorithm development, Flowcharting, Stepwise refinement. Structured programming; Object oriented programming, classes, objects, Abstract data types, Data types, Operators (Arithmetic, Logical and Comparison) and expressions. Branching and iteration, Arrays, Object/Message paradigm. Data encapsulation- modules and interfaces; Polymorphism - Static and dynamic binding, Inheritance: class and object inheritance. Object oriented software design; Generic and reusable classes, Debugging and testing of programs. Database system - Operational Data, Characteristics of database approach, architecture. Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification. Entity Relationship model; Relational Data Structure- Relations, Domains
and Attributes, Relational Algebra and Operations, Retrieval Operations. Relational Database Design - Anomalies in a Database, Normalization Theory, and Normal forms; Query processing and optimization; Security, backup and recovery. Distributed Databases-concepts, architecture, design; Object Oriented databases; Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML), Query by example. PL/SQL - Stored procedure, Database triggers; Relational Data Base Management Package.

Module 4

Introduction to Bioinformatics

Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.). Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jackknifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling. DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools. Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics.

Practicals:

1. Introduction to Bioinformatics database
2. Statistical Test like MANOVA, Cluster analysis, Discriminant analysis, PCA etc with R package.
3. Protein structure visualization
4. Homology model of a protein
5. Phylogeny analysis

Suggested Readings

Date, C. J. 2000. Introduction to Database System. Addison Wesley.
Module I
Cell theory; cell division (mitosis and meiosis)
Structure and Molecular organization of chromosomes; special chromosomes (lampbrush chromosomes, polytene chromosomes, B-chromosomes); Karyotype and its evolution
Variations in chromosome: Numerical variations (heteroploidy), aneuploids and euploids- their occurrence, inheritance, subtypes and significance; structural variations- their occurrence, inheritance, subtypes and significance

Module II
History of genetics; Mendelism: Mendel’s work on pea, laws of inheritance; deviations from Mendel’s findings: incomplete dominance, codominance, multiple alleles, isoalleles, modifier genes, suppressor genes, pleiotropic genes
Chromosome theory of inheritance
Lethal genes: Penetration and expressivity, Dominant and recessive lethals, balanced lethal system

Module III
Non-Mendelian inheritance: Maternal effect; Cytoplasmic inheritance
Linkage and crossing over; genetic and cytological mapping; tetrad analysis
Polygenic inheritance: Multiple gene hypothesis; examples- skin colour in humans and flower length of tobacco,
Pure lines of Johannsen and multiple factor hypothesis; simple and complex quantitative traits
Sex determination: Sex-linked, sex-influenced and sex-limited characters; mechanism of sex determination-
Chromosomal, genic and environmental

Module IV
Chemical nature of gene: Nucleic acid as genetic material; Prions; structure of nucleic acids
Fine structure of gene; position effect; pseudoalleles
Overlapping genes; pseudogenes; Retrogenes; cryptic genes
Epigenetics: Paramutations; Callipygh sheep; Histone code; DNA methylation; genomic imprinting; epigenetics and Lamarckism

Suggested reading
Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4thed.). Jones and Barflett Publishers, USA.
Course code/name:

Foundation Course I: BIOSTATISTICS I
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

MODULE I: INTRODUCTION AND DATA 15 Hrs

A) INTRODUCTION TO STATISTICS AND BIOSTATISTICS:
   a) Definition, History, Meaning and Scope of Statistics and Biostatistics;

B) TYPES OF DATA:
   Measurements and Counts; Biological data; Quantitative and Qualitative data; Biological Data Types...Measurement and Measurement Scale: Data on Nominal scale, Ordinal scale, Interval scale and Ratio scale;

C) PRESENTATION OF DATA:
   a) Raw Data and Treated Data;
   b) Presentation of Data in Table form... Simple Tables, An Ordered Array; Frequency Table/Distribution.....Preparation of Frequency table for Data at various scales; Modifications of frequency distribution; Two-way Classification; Presentation of Data in Graphical form... Line diagram, Bar Graph and its various modifications, Histogram, Frequency Polygon, Cumulative Frequency distribution and Ogive, Pie chart, Pictogram, Stem and Leaf Display.

MODULE II: ANALYSIS OF QUANTITATIVE DATA 15 Hrs

MEASURES OF LOCATION (CENTRAL TENDENCY):
   a) Essential Features of a good Measure of Central Tendency;
   b) Types of Measures of Central tendency in different Situations (For numerical data, Discrete and Continuous data, Frequency distribution
Arithmetic Mean, The Median (also for Tied Data), and The Mode (and Unimodal, Bimodal distribution etc.);
   c) Other Quantiles e.g., Quartiles, Octiles, Percentiles;
   d) Other Measures of Central Tendency e.g., Weighted Mean, Grand Mean, Geometric Mean, Harmonic Mean etc.(all basic concepts);
   e) The Effect of Coding Data... Coding by Subtraction and Coding by Division
   f) Merits and Demerits of Important Measures of Central Tendency and their applications;
   g) Interrelationship between Mean, Mode and Median

MODULE III: MEASURES OF DISPERSION OR VARIABILITY 15 Hrs

Types of Measures of Dispersion In different Situations (For numerical data, Discrete and Continuous data, Frequency distribution etc., Use of different Formulae; The Range Interquartile range, The Mean Deviation (M.D.); The Variance;The Standard Deviation (S.D.) [in case of simple data, continuous and discontinuous data, large data etc.]; The Coefficient of Variation (COV); The Indices of Diversity...Concept of Homogeneity or relative Diversity; The Effect of Coding Data on Sample Statistics

MODULE IV: Random variables and probability distribution 15 Hrs

Discrete and continuous random variables, binomial distribution, poisson distribution and their properties.
NORMAL DISTRIBUTION:
- Continuous distribution;
- The Concept of Normal distribution;
- Concept of Symmetry and skewness and kurtosis
- properties of A Normal Distribution
- The distribution of Means…Concept, Importance of Standard Error of Mean and Normal Deviate (Z score):

[Note: Students Can Be Taught Writing Statistical Equations Using Microsoft Word Program... Equations and Symbols]


8. Principles of Genetics By Tamarin,

9. Cell Biology By De Robertis and De Robertis
Semester IV

Course code/name:

**MBGE XIII (4T1) PLANT AND ANIMAL TISSUE CULTURE**
*(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)*

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**Module I**

15L

Conventional Plant breeding technique.
History of tissue culture technique.
Plant tissue system and importance of macro and micro elements.
Role of photoperiod, humidity and temperature on plants and in-vitro culture.
Nutrient media composition of commonly used nutrient culture media like MS (1962),
Laboratory organization and requirements of Plant tissue culture lab.
Totipotency of plant cell, De-differentiation and Re-differentiation.

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**Module II**

15L

Explant isolation technique, In-vitro culture, Initiation and maintenance of callus,
suspension culture, growth curve.
Micropropagation shoot tip culture, Rapid clonal propagation and Production of virus
free Plant.
Embryo culture and embryo rescue technique.
Anther and ovary culture. Germplasm conservation, cryopreservation, slow growth,
DNA banking, Protoplast isolation and culture technique.

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**Module III**

15L

Animal Tissue Culture

Media for cultured cells & tissues – natural & defined media.
Preparation of various tissue culture media, sterilization and sterility testing.
Setting up of primary cultures of Fibroblast cells from neonatal rat skin for establishment of continuous cell lines.
Maintenance of continuous cell lines in the laboratory.
Cell hybridization, use of hybridoma cell lines for the production of monoclonal antibodies.
Cryopreservation of cells, embryos, ova and semen.
Embryonic Stem cells – isolation, culture and preservation.

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**Module IV**

15L

Animal improvement

Conventional methods of animal Improvement – Selective Breeding and Cross breeding.
Embryo Biotechniques for augmentation of replication efficiency and faster multiplication
of superior germplasm, Super ovulation, Oestrus synchronizaion, embryo collection and transfer.
*In vitro* culture of oocytes, *in vitro* fertilization, embryo culture and preservation.
Micromanipulation and cloning, Somatic cell cloning, Embryo sexing.
Identification and isolation of genes of economic importance.
Production of animals as bioreactors for proteins of pharmaceutical value.
Gene mapping in farm animals.
Marker assisted selection and genetic improvement of live stocks.
Practical:
1. Media Preparation
2. Meristem and axillary bud culture
3. Organogenesis & SE
4. Embryo Rescue Technique
5. Anther /Pollen culture technique

Animal tissue culture based practicals
6. Preparation of Tissue culture medium & membrane filtration.
7. Cell counting and cell viability.
8. Cryopreservation and thawing.
9. Role of serum in cell culture.
10. Isolation of DNA from cell culture.

Books Recommended:
2. Plant Tissue Culture - Akio Fujiwara
3. Frontiers of Plant Tissue Culture - Trevor A. Thorpe
4. In Vitro Haploid Production of Higher Plants - S. Mohan Jain, S.K. Sopory, R.E. Veilleux
5. Plant Tissue Culture : Theory and Practice - S.S. Bhojwani and A. Razdan

Recommended Books:
1. C. Helgasson; Basic cell culture protocols, 3rd edition, Human press
3. J. Mather and d. Barnes; Animal cell culture methods, Elsevier, vol 57
5. J. Paul Basic Protocols in cell and tissue culture
6. M. Butler; Animal cell technology-Principles and products, Open University press
7. M. Butler and M. Dawson, Cell culture lab. fax, Bios scientific Pvt. Ltd.
8. M. Cylnes; Animal cell culture techniques, Springer Verlag
10. N. Jenkins; Animal cell biotechnology-Methods and protocols, Human Press
13. S. Sasidhara animal Biotechnology, MJP Pub. Chennai
Course code/name: MBGE XIV (4T2):  
RECOMBINANT DNA TECHNOLOGY II  
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1:  
15L  
DNA synthesis, Nucleic Acid Sequencing methods, separation, cloning, Molecular Tools and Their Applications: Restriction enzymes, modification enzymes, DNA, and RNA markers, Restriction mapping of DNA Fragments and map construction. Formation of Point mutations and molecular mechanism

Module 2:  
15L  
Molecular Mapping of genome: Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat loci, Southern and fluorescence in situ hybridization for genome analysis, chromosome micro-dissection and micro-cloning, molecular markers (PCR and non-PCR based) in genome analysis, molecular markers linked to disease resistance genes.

Module 3:  
15L  
Site-directed Mutagenesis and Protein Engineering  
How to Study Gene Regulation? DNA transfection, Northern blot, Primer extension, S1 mapping, RNase protection assay, Reporter assays. Expression Strategies for Heterologous Genes Vector engineering and codon optimization, host engineering, In vitro transcription and translation, expression in bacteria, Yeast, insects and insect cells, mammalian cells, and in plants. Processing of Recombinant Proteins: Purification and refolding, characterization and stabilization

Module 4:  
15L  

Practicals:  
1. Isolation of DNA and its quantification (plant, animal, bacterial)  
2. Isolation, purification, quantification and separation of plasmid DNA  
3. RAPD, RFLP analysis from microbe genome.  
4. DNA sequencing  
5. Gel electrophoresis of DNA  
6. Extraction of DNA from Gel
7. Detection of transposon through bacterial conjugation

**Recommended Books:**

1. Molecular Biology of the gene - J. Watson
2. Genes VI, VII and VIII - Benjamin Lewin
3. Molecular Biotechnology Principles and application of recombinant DNA
4. Molecular Biology - Robert F. Weaver
5. Recombinant DNA: A short course - J. Watson, Tooze and Kurtz
6. Molecular Biology - J. Watson
Module I
Cloning: Isolation of single cells, culturing of single cell - Different methods, viability test of cultured cells, role of hormones in morphogenesis.
Somatic embryogenesis: Physical and chemical factors responsible for induction of somatic embryos, molecular basis of somatic embryogenesis, genotype specificity of somatic embryogenesis.
In-vitro pollination and fertilization, overcoming barriers to wide hybridization, production of dihaploids and their application in genetics and plant breeding, polyploids through endosperm culture and their application in plant breeding.

Module II
Genetic resources, germplasm conservation, gene bank – some case studies on success stories on commercial application of plant tissue culture, abiotic stress resistant: isolation and culture of salt tolerant cell lines.
Production of secondary metabolites through cell culture technique in some important medicinal plants, factors affecting production, biotransformation, elicitors induced production, hairy root culture and production of secondary metabolites.

Module III
Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation, nutrient uptake efficiency.
Genetic engineering for abiotic stress like drought, flooding, salt and temperature.
Genetic engineering for quality improvement of protein, lipids, carbohydrates, vitamins and mineral nutrients. RNAi approach
Chloroplast transformation – advantages, vectors and success.

Module IV
Molecular characterization of transgenics for gene integration – PCR, Southern blot, gene expression, Western blot, ELISA, marker free methodologies, gene stability, gene silencing, gene staking,
Conained green house trial, field trial of transgenic plants, selection of promising events, point of integration, RCGM, GEAC.

Practicals:
1. Induction of shoots from shoot tip in MS medium containing growth regulators
2. Induction of callus and somatic embryogenesis in monocot plants
3. Anther culture and production of haploid callus
4. Induction of callus and isolation of salt tolerant cell line
5. Induction of hairy roots and production of secondary metabolites
6. Transformation of gus gene in plants through Agro-bacterium
7. Amplification of transgene from plant by PCR
8. Cell suspension culture
9. Endosperm culture

Books Recommended:
2. Plant Tissue Culture - Akio Fujiwara
3. Frontiers of Plant Tissue Culture - Trevor A. Thorpe
4. In Vitro Haploid Production of Higher Plants - S. Mohan Jain, S.K. Sopory, R.E. Veilleux
5. Plant Tissue Culture: Theory and Practice - S.S. Bhojwani and A. Razdan
Course code/name: Elective Paper II:

MBGE XV (4T4) : MOLECULAR DIAGNOSTICS
(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

MODULE 1:
15L
Infection mode of transmission of diseases caused by fungi, protozoa’s, helminthes; types of infectious diseases. Diagnosis of infections caused by fungi such as Dermatophytoses, Candidiosis and Aspergillosis; caused by protozoa’s such as Amoebiosis, Malaria, Trypnosomiosis, Leishmaniasis; caused by helminthes such as Fasciola hepatica, Ascaris lumbricoides, Filariasis and Schistosomiasis;

MODULE 2:
15L
Infections caused by bacteria such as Streptococcus, Coliforms, Salmonella, Shigella, Vibrio and Mycobacterium; caused by viruses such as adenoviruses, Rhabdo viruses, Hepatitis virus and retroviruses caused by nematodes/cestodes such as taeniasis and H.nana infection, bacterial food poisoning, cholera, E.coli diarrhea. Sexually Transmitted Diseases such as HIV, AIDS, Syphilis, Gonorrhea and others

MODULE 3:
15L

MODULE 4:
15L

Practicals:

PCR for 16S RNA from bacteria
PCR RFLP for Factor V Leiden mutation
PCR RFLP for Sickle cell anemia
Mutation analysis by sequencing for Thalassemia-Demo
Mutation analysis by Genotyping for Huntington disease-Demo
DNA Fingerprinting-Demo
Genetic basis of male infertility in humans.
**Recommended Books:**

1. Wayne, W., Grody, Robert M. Nakamura, Charles M. Strom and Frederick L. Kiechle *Molecular Diagnostics: Techniques and application for the clinical laboratory.*

2. William B. Coleman and Gregory J. Tsongalis *Molecular Diagnostics: For the clinical laboratories.*

Course Code: Elective paper II
MBGE (4T4)XI: Bioinformatics and Data Mining-Advanced Course

(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1

BIOLOGICAL DATABASES AND DATA ANALYSIS:
Nature of biological data; Overview of available Bioinformatics resources on the web; NCBI/ EBI/EXPASY etc; Biological Databases: Nucleic acid sequence databases; GenBank/EMBL/ DDBJ; Biological Databases: Protein sequence databases; PIR-PSD; SwissProt, UniProtKB; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms: Needleman & Wunsch, Smith & waterman; Scoring matrices for Nucleic acids and proteins: MDM, BLOSUM, PAM, CSW; Database Similarity Searches: BLAST, FASTA; Multiple sequence alignment: PRAS, CLUSTALW; Biological databases: Genome & genetic disorders; Genome databases: Human, model organisms, microbes & viral: OMIM; Biological databases: structural databases: PDB, NDB, CCSD; Derived databases: Prosite, BLOCKS, Pfam/Prodrom.

Module 2

RNA/PROTEIN STRUCTURE PREDICTION AND MOLECULAR MODELING:
Structural data, databases and structure analysis: Exploring the Database searches on PDB and CSD, WHATIF Molecular visualization tools; Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins and DNA using molecular visualization softwares such as RasMol, Cn3D, SPDBV, Chime, Mol4D etc. Structure prediction tools and homology modeling: Prediction of secondary structures of proteins using different methods with analysis and interpretation of the results; Comparison of the performance of the different methods for various classes of proteins. (Fasman method, Garnier Osguthorpe Robson (GOR), Neural Network based; methods); NLP approach for secondary structure prediction of RNA; Introduction to mfold and Vienna packages; Prediction of tertiary structures of proteins using Homology Modeling approach: SWISSMODEL, SWISS-PDB Viewer; Prediction of tertiary structures of proteins different methods for fold recognition along with analysis and interpretation of results (Threading techniques; Homology Modeling and abinitio methods). Molecular dynamics simulation and docking: Basic principles of theoretical modeling, Empirical force fields for biomolecular simulations, Energy minimization, Molecular dynamics, Monte Carlo simulation Peptide building (PYMOL / DStools ).
Module 3
Advanced Bioinformatics:

Module 4
TOOLS AND TECHNIQUES FOR BIOLOGICAL DATA MINING:
Techniques: Hidden Markov Model, Neural 356 Network, Bayesian modeling, The Cox-Jaynes Axiomes; Support Vector machine & Ant colony optimization: Multiple Sequence Alignments, Biomolecular Structure Prediction; Fuzzy logic system & application in bioinformatics; Introduction to WEKA package; Clustering and classifications, Protein Array data Analysis.

Practicals:
Nucleic acid sequence databases, Protein sequence databases, Database search engines, Database Similarity Searches, Multiple sequence alignment, Genome databases, Structural databases, Derived databases
Structural data, databases and structure analysis, Molecular visualization tools, Structure prediction tools and homology modeling, Molecular dynamics simulation and docking
Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods, Statistical methods to discover common motifs in biosequences, Multiple alignment and database search using motif models, ClustalW, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models, Computational analysis of protein sequence, Expression profiling by microarray/gene chip, proteomics, Modelling and prediction of structure of proteins, Bayesian techniques and use of Gibbs Sampling, Analysis of DNA microarray experiments, Analysis of one DNA sequence, Analysis of multiple DNA or protein sequences, Computationally intensive methods, Multiple Hypothesis testing, Phylogenetic tree estimation, Analysis of SNPs and Haplotypes. 354

Suggested Readings
Course code/name:

Foundation Course II: BIOSTATICS II

MODULE I: PROBABILITY THEORY  
A) Important Terms, Basic Concept of Probability:  
Sample space, Events (Different Types... Null, Simple, Compound, Exhaustive (Cases), Collectively Exhaustive, Mutually Exclusive, Dependent and Independent Events, equally Likely, Equally Probable, And Favourable);  
B) SOME RULES OF PROBABILITIES:  
a) Probabilities and Odds;  
b) Addition Rules/Theorem on Total Probability (and Rule for Calculating Probability of an Event);  
c) Independent Events;  
d) Multiplication Rules/Theorem on Compound Probability (Conditional Probability);

MODULE II: Statistical Inference  
A) ESTIMATION:  
a) Theory of Point Estimation;  
b) Confidence Intervals for Means...  
i) For Large Samples (Z score),  
ii) For Small Samples with unknown population S.D. ( \( t \) test); Confidence Intervals for Standard Deviation  
1. CONCEPTS OF TESTS OF HYPOTHESIS:  
a) Null Hypotheses (Simple and Composite, One-Sample and Two-Sample);  
b) Significance Tests.. 1) One-tailed and 2) Two-tailed tests;  
c) Statistics for Tests Concerning Means... Z score; Small Samples (t test);  
d) Tests Concerning Differences among Means...  
1) Statistic for large-sample test concerning difference between two means (Z statistic)  
2) Statistic for Small-sample test concerning difference between two means (t statistic)  
3) Statistic for test concerning differences among means.

MODULE III SAMPLING AND SAMPLING THEORY  
A) SAMPLING THEORY AND TYPES OF SAMPLES:  
a) Concept of population and sample drawn from population, concept of random sample  
b) Types of Sampling... Meaning, Factors, Advantages and Drawbacks  
Probability Sampling—  
Simple Random Sampling, Systematic (Interval) Sampling, Stratified Sampling.  
ii) Non-Probability Sampling—  
1) Convenience (haphazard) Sampling, 2) Volunteer Sampling, 3) Judgment Sampling, 4) Quota Sampling.

MODULE IV ANALYSIS OF COUNT DATA AND PAIRED DATA  

A) ANALYSIS OF COUNT DATA:
   a) The Estimation Of Proportions
      Use of Z score, Maximum error of Estimate and Determination of Sample Size

B) STATISTIC FOR TEST CONCERNING DIFFERENCES AMONG PROPORTIONS:
   a) Chi square test ($\chi^2$ test) and its use in Genetics;
   b) Application or Role of $\chi^2$ test in Contingency (row and column) Tables [for Trials permitting
      more than two possible outcomes (r X c table)];
   c) Application or Role of $\chi^2$ test in Goodness of Fit

C) ANALYSIS OF PAIRED DATA:
   a) Regression and Correlation Analysis
      i) Meaning and Comparison
         ii) Simple Regression and Simple Correlation
            Estimation of parameters by method of least squares; test of significance of regression
            and coefficient; $F$ test and ANOVA; Standard Error Of Estimate; Coefficient of Correlation ($r$) and
            $t$-testing
            Regression through Origin
   c) Correlation Analysis
      1) Understanding Correlation of Determination ($r^2$) and Coefficient of Correlation ($r$),
      2) Preparation of Scatter Plot,
      3) Finding the values of Correlation of Determination ($r^2$) and Coefficient of Correlation ($r$),
      4) Assumptions of Correlation Analysis,
      5) Testing the Hypothesis about the Correlation Coefficient…
         • ANOVA and $F$ test,
         • $t$-test
Module I
Population genetics: Gene pool and gene frequencies; Hardy-Weinberg's law; factors affecting Hardy-Weinberg's equilibrium- mutation, migration, genetic drift and selection; Random drift and Wright-Fisher model; molecular population genetics- AMOVA; genetic distance; genetic relatedness and identity; detection of selection events; coalescent theory
Behavioural genetics: History; evidences for genetic basis of behavior; methods for genetic analysis of behavior; Examples- Courtship in *Drosophila*, temperament in mammals, emotional stability and schizophrenia; effect of environment on behavior; ethical and social issues

Module II
Evolutionary genetics: Theories of organic evolution; mutation theory; original synthetic theory; evolution at molecular level; processes of creating variation; genotype and phenotype spaces; genetics of speciation- species and races, concept of species; isolating mechanisms; adaptive landscapes and speciation; models of speciation; molecular genetics of speciation; speciation revolution
Developmental genetics: Introduction; Pattern formation in *Drosophila*- development, egg-polarity genes, segmentation genes, homeotic genes, epigenetic changes; flower anatomy and genetic control of flower development

Module III
Plant breeding: Genetic basis of plant breeding; Methods of breeding sexually (self- and cross-pollinated) and vegetatively propagated crops; Genetic basis of inbreeding depression and heterosis; Self-incompatibility; male sterility- types and its use in plant breeding; Molecular plant breeding; Crop genetic resources; seed production and certification

Module IV
Eugenetics: Human karyotype- Chromosome number and morphology, banding, FISH, McFISH; Genetic disorders- Turner's syndrome, Klinefelter's syndrome, Down's syndrome, Patau syndrome, superfemale; Dizygotic and monozygotic twins; Chromosome mapping in humans- linkage maps, molecular maps, transcript map; Use of human genetics in medical science- Chromosome or DNA tests

References
Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4thed.). Jones and Barflett Publishers, USA.
Foundation course II (For students other than MOL. BIO. & GEN. ENG.)

Course code/name: MBGE(T): RECOMBINANT DNA TECHNOLOGY AND PLANT GENETIC ENGINEERING

(Total CREDITS 4, 1 CREDIT FOR EACH MODULE)

Module 1: 15L
Scope of Recombinant DNA Technology, Milestones in Genetic Engineering, Restriction enzymes, modification enzymes, DNA markers, Cutting, joining and modifying and amplifying DNA, Gene Cloning Vectors Plasmids, bacteriophages, phagemids, cosmids, Artificial chromosomes, molecular markers in genome analysis (RFLP, RAPD and AFLP).

Module 2: 15L
Methods of gene transfer techniques in plants and animals (Agrobacterium mediated, electrophoration and particle gun, liposome, PEG), principles of cell based DNA cloning, importance of cloning, construction and screening of genomic libraries.
Polymerase Chain Reaction: Basic features, optimization of PCR parameters, variations in PCR and applications.

Module 3: 15L
Nucleic acid hybridization: Preparation of probes, principles & applications of nucleic acid hybridization, nucleic acid in situ hybridization assays - Southern, Northern and Western methods, Dot and Slot methods, various types of Nucleic Acid Sequencing methods.

Module 4: 15L
Plant Transformation technology for Transgenic production: Basis of tumor formation, hairy root features of Ti and Ri plasmids, mechanisms of DNA transfer, Role of virulence genes, use of Ti and Ri as vectors, binary vectors, Application of Plant Transformation for productivity and performance: Herbicide Resistance: phosphinothricin, glyphosate, sulfonyl urea, atrazine; Insect resistance: Bt genes, Non-Bt like Protease Inhibitors, alpha amylase inhibitor; Virus resistance: Coat protein mediated, nucleocapsid gene; Disease resistance: Chitinase, 1-3 beta glucanase, RIP, antifungal proteins, thionins, PR proteins; Nematode resistance; Abiotic stress

Recommended books:

### SEMESTER I

**M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING**

**PRACTICAL I**

<table>
<thead>
<tr>
<th>Time: 12 Hours</th>
<th>Full Marks: 100 (Ex. Ass.)</th>
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<tr>
<td>Q.1 Practical from course I</td>
<td>25</td>
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<tr>
<td>Q.2 Practical from course II</td>
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<tr>
<td>Q.3 Comment on the spots from course I, II</td>
<td>10</td>
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<tr>
<td>Q.4 Viva-Voce</td>
<td>20</td>
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<tr>
<td>Q.5 Practical records</td>
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### SEMESTER I

**M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING**

**PRACTICAL II**

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<tr>
<td>Q.2 One minor practical from course IV</td>
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<tr>
<td>Q.3 One major practical from course III or IV</td>
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<td>Q.4 Comment on the 2 spots from course III, IV</td>
<td>10</td>
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<tr>
<td>Q.5 Viva-Voce</td>
<td>20</td>
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<tr>
<td>Q.6 Practical records</td>
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SEMESTER II

M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

PRACTICAL III

TIME : 12 HOURS

FULL MARKS : 100 (Ex. Ass.)

Q.1 One minor practical from course V 15
Q.2 One minor practical from course VI 15
Q.3 One major practical from course V or VI 20
Q.4 Comment on the 2 spots from course V, VI 10
Q.5 Viva- Voce 20
Q.6 Practical records 20

SEMESTER II

M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

PRACTICAL IV

TIME : 12 HOURS

FULL MARKS : 100 (Ex. Ass.)

Q.1 Practical from course VII 20
Q.2 Practical from course VIII 20
Q.3 Minor Practical from course VIII 10
Q.4 Comment on 2 spots from course VII, VIII 10
Q.5 Viva- Voce 20
Q.6 Practical records 20
SEMESTER III

M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

PRACTICAL V

TIME : 12 HOURS

Q.1 One practical from course IX 20
Q.2 One practical from course X 30
Q.3. Comment on Two spots 10
Q.4. Viva- Voce 20
Q.5. Practical records 20

FULL MARKS : 100 (Ex. Ass.)

SEMESTER III

M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

PRACTICAL VI

TIME : 12 HOURS

Q.1 One major Practical from course XI 30
Q.2. One minor Practical from course XI 20
Q.3. Comment on the 2 spots from course 10
Q. 4. Viva- Voce 20
Q. 5. Practical records 20

FULL MARKS : 100 (Ex. Ass.)

SEMESTER IV

M.Sc. EXAMINATION IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

PRACTICAL VII

TIME : 12 HOURS

Q.1 Two practicals from course XIII, XIV 20
Q. 2. One major practical from course XV 30
Q. 3. Comment on two spots 10
Q.4. Viva- Voce 20
Q.5. Practical record 20

FULL MARKS :100 (Ex. Ass.)
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