DURATION : Four Semesters (Two Years)
Total Marks = 4000
Theoretical Papers
18 Papers (Marks = 1800)
Total Credit = 54

Practical / Project Papers
Total Marks = 1800)
Total Credit = 36
Total Credit in 4 Semesters = 54 + 36 = 90

3 credit (Theory) means 4 lecture hours per week or 42 lectures per semester per paper

2 credit (Lab.) means at least 40 hours of lab work per semester per paper

FIRST SEMESTER

Paper (Theoretical) : 5 Papers = 500 Marks

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSGEN-101	**Transmission Genetics & Analysis**	100	3	42
MSGEN-102	**DNA Structure & Gene Expression**	100	3	42
MSGEN-103	**Chromosome structure & Function**	100	3	42
MSGEN-104	**Genetics of Organelles**	100	3	42
MSGEN-105	**Biophysics & Biochemistry**	100	3	42

Paper (Practical) : 5 Papers = 500 Marks

MSGEN-106	**Microscopy & Instrumentation**	100	2	40 hrs
MSGEN-107	**Molecular Biology – Basic techniques**	100	2	40 hrs
MSGEN-108	**Basic Cyto-Genetics Techniques**	100	2	40 hrs
MSGEN-109	**Cell Culture Techniques (Plant & Animal)**	100	2	40 hrs
MSGEN-110	**Biophysical & Biochemical Techniques**	100	2	40 hrs

Total Credits = 25

Syllabus for two-year
M.Sc COURSE **in**
Genetic Engineering
SECOND SEMESTER

Paper (Theoretical) : 5 Papers = 500 Marks

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSGEN-201	**Principles of Microbiology**	100	3	42
MSGEN-202	**Genetics of Model Organisms**	100	3	42
MSGEN-203	**Principles of Molecular Cell Biology**	100	3	42
MSGEN-204	**Genetic Biodiversity and Taxonomy**	100	3	42
MSGEN-205	**Quantitative Analysis**	100	3	42

Paper (Practical) : 5 Papers = 500 Marks

MSGEN-206	**Microbiological Techniques**	100	2	40 hrs
MSGEN-207	**Life Cycle Studies (Model organisms)**	100	2	40 hrs
MSGEN-208	**Genetic Engineering Tools- I**	100	2	40 hrs
MSGEN-209	**Genetic Toxicity Testing**	100	2	40 hrs
MSGEN-210	**Computer Application**	100	2	40 hrs

Total Credits = 25

THIRD SEMESTER

Paper (Theoretical) : 5 Papers = 500 Marks

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSGEN-301	**Engineering of Genes and Genomes**	100	3	42
MSGEN-302	**Genomics, Proteomics & Bioinformatics**	100	3	42
MSGEN-303	**Microbial Biotechnology**	100	3	42
MSGEN-304	**Spl. Paper : (any one)** **(i) Medical Biotechnology - I** **(ii) Plant Biotechnology – I** **(iii) Animal Biotechnology - I** **(iv) Environmental Biotechnology - I**	100	3	42
MSGEN-305	**Spl. Paper : (any one)** **(i) Medical Biotechnology - II** **(ii) Plant Biotechnology – II** **(iii) Animal Biotechnology - II** **(iv) Environmental Biotechnology - II**	100	3	42

Paper (Practical) : 5 Papers = 500 Marks

MSGEN-306	**Genetic Engineering Tools- II**	100	2	40 hrs
MSGEN-307	**Bioinformatics**	100	2	40 hrs
MSGEN-308	**Microbial Biotechnology**	100	2	40 hrs
MSGEN-309	**Spl. Paper : (any one)** **(i) Medical Biotechnology - I** **(ii) Plant Biotechnology – I** **(iii) Animal Biotechnology - I** **(iv) Environmental Biotechnology - I**	100	2	40 hrs
MSGEN-310	**Spl. Paper : (any one)** **(i) Medical Biotechnology - II** **(ii) Plant Biotechnology – II** **(iii) Animal Biotechnology - II** **(iv) Environmental Biotechnology - II**	100	2	40 hrs

Total Credits = 25

FOURTH SEMESTER

Paper (Theoretical) : 4 Papers = 400 Marks

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSGEN-401	**Genetic Engineering in Business**	100	3	42
MSGEN-402	**Bioethics & Biosafety**	100	3	42
MSGEN-403	**Spl. Paper : (any one)** **(i) Medical Biotechnology - III** **(ii) Plant Biotechnology – III** **(iii) Animal Biotechnology - III** **(iv) Environmental Biotechnology - III**	100	3	42

Paper (Practical) : Total = 300 Marks

MSGEN-404	**Independent Project Work in Academia and / or Industry**	300	6	120 hrs

Total Credits = 15

Syllabus for two-year
M.Sc COURSE **in**
Genetic Engineering
THEORETICAL PAPERS

MSGEN-101 : Transmission Genetics & Analysis

1. **Introduction to Genetics –** Great milestones in Genetics; levels of Genetic analysis (Classical, Molecular & Population Genetics); Genetics in Agriculture, Medicine & Society.

2. **Cells & Chromosomes -** Basic cell types – structure & evolutionary relationships, Overview of Prokaryotic & Eukaryotic cells, Cellular environment, Chromosomes – where genes are located.

3. **Genetics of Cell Cycle –** Key events of the Cell cycle, Genetic analysis of the Cell cycle, Regulation of cell cycle, Checkpoints in the cell cycle.

4. **Basic principles of Heredity –** Segregation of a single gene, the principle & verification of segregation, segregation of two or more genes, test cross with unlinked genes**.**

5. **Patterns of Inheritance –** Autosomal inheritance, Sex chromosomes & Sex-linked inheritance, Cytoplasmic inheritance.

6. **Mendelian principles of Inheritance –** The Big experiment of Mendel, principle of independent assortment.

7. **Extensions & Modifications of Mendelian principles –** Complete & Incomplete dominance, Epistasis.

8. **Linkage, Recombination & Crossing Over –** Recombination is the basis of Gene mapping, Linkage mapping, Tetrad analysis, Gene mapping in absence of Meiosis, Genetic Fine structure mapping.

9. **Genetic Variation –** Genes & gene products, interaction between the alleles of one gene, interacting genes & proteins, applications of chi-square test to gene interaction ratios.

10. **Alleles & Gene Interactions –** Variations in Allele, Multiple alleles, Gene interactions, Alleles of different genes, Modifier genes, Pleiotropic effects, Partial penetrance & variable expressivity, Lethal alleles, Phenotypes produced by Conditional alleles**.**

11. **Quantitative Traits & Polygenic Inheritance –** Inheritance of Quantitative traits, Genetic analysis of Quantitative traits using Statistics, Usefulness of Heritability in predicting the phenotypes of offsprings.

12. **Extra-nuclear Inheritance –** Chromosomes of some cytoplasmic organelles, Maternal inheritance, Paternal inheritance, Effect of Maternal genes in the phenotype of offspring, Infectious inheritance.

13. **Pedigree analysis & Applications –** Study of Human Genetic Characteristics, Pedigree analysis, Molecular markers in Human Pedigrees, Twin studies, Adoption studies, Genetic Counseling, Genetic Testing (Pre-natal & Post-natal).

14. **Morphological & Molecular phenotypes –** Appearance of wild type & mutant characteristics, molecular mechanism behind phenotypic expressions.

15. **Probability in prediction of progeny distribution –** Mutually exclusive possibilities & Independent possibilities.

16. **Testing of Genetic hypothesis –** Probability in the prediction of progeny distributions using Binomial distribution, Testing Goodness of Fit to a Genetic hypothesis, Chi-square method, Genetic analysis of quantitative traits using Statistics (Mean, Variance, Standard deviation, Correlation, Regression, Distributions), Heritability is useful in predicting the phenotypes of offspring.

References :

(1) Daniel L. Hartl & Elizabeth W. Jones : Genetics – analysis of Genes & Genomes
(2) Alan G. Atherly, Jack R. Girton & John F. McDonald : The Science of Genetics

(3) Benjamin A. Pierce : genetics – a conceptual approach
(4) D. Peter Snustad & Michael J. Simmons : Principles of Genetics
(5) Griffiths, Wessler, Lewontin, Gelbart, Suzuki & Miller : Introduction to Genetic analysis

MSGEN-102 : DNA Structure & Gene Expression

1. **Introduction to Molecular Genetics & Genomics –** History of DNA molecule & discoveries since 1956 till date.

2. **Physical nature of DNA –** DNA is the genetic material, Chemical nature of DNA, DNA is a Double helical molecule.

3. **How Genes function at Molecular level –** Replication, Transcription & Translation, post-transcriptional modification in Eukaryotes, The Genetic Code.

4. **Molecular Biology of DNA Replication -** DNA replication is semi-conservative, Meselson-Stahl expt., Multiple Origins & bi-directional DNA replication in Eukaryotes, Replication of Virus & Theta replication of Circular DNA molecules, Rolling Circle replication, Plasmid DNA using a Rolling Circle, Unwinding, Stabilization & Stress relief, initiation by a Primosome complex, Chain elongation & Proofreading, discontinuos replication of the lagging strand, Terminator sequencing of DNA.

5. **Molecular Biology of Recombination -** Molecular mechanisms of Recombination, Gene conversion, Mismatch repair, the Holliday model of recombination, Single strand break & repair model.

6. **Regulation of Gene Expression –** Regulation of gene expression at many levels, Transcriptional Control I, expression of *lac* operon, Transcriptional Control II, Attenuation, Antitermination, Methylation, Yeast GAL regulatory pathway, alteration of gene expression by DNA sequence rearrangements in *Salmonella*, *Trypanosoma* & others.

7. **Genomic Position effects on Gene Expression –** Position effect, Variegation,, Position-effect variegation (PEV).

8. **Molecular mechanisms of Gene Regulation –** Transcriptional regulation in Prokaryotes, Lactose metabolism & the Operon system of Gene regulation, regulation of Tryptophan operon, regulation in Bacteriophage Lambda, Transcriptional regulation in Eukaryotes, Epigenetic mechanisms of Transcriptional regulation, Translational control, Programmed DNA rearrangements.

9. **RNA Molecules & RNA Processing –** Gene structure, Structure & Processing of messenger RNA, transfer RNA, ribosomal RNA, small interfering RNAs & micro RNAs, regulation through RNA processing & decay, alternative splicing, mRNA stability,co-suppression through RNA turnover, RNA interference (RNAi).

10. **Molecular mechanisms of Mutation & DNA Repair –** Types of Mutations, molecular basis of Mutation, Spontaneous Mutation, Reverse Mutations & Suppressor Mutations, Transposable elements, Mutagens, mechanism of DNA Repair.

11. **The Genetic Code & Translation –** Molecular relation between Genotype & Phenotype, The Genetic Code, Process of Translation, Protein synthesis.

References :

1) Daniel L. Hartl & Elizabeth W. Jones : Genetics – analysis of Genes & Genomes
2) Alan G. Atherly, Jack R. Girton & John F. McDonald : The Science of Genetics
3) Benjamin A. Pierce : genetics – a conceptual approach

MSGEN-103 : Chromosome Structure & Function

1. **An overview of Chromosome –** Overview of Prokaryotic & Eukaryotic chromosomes

2. **Chromosome Theory of Heredity –** Genes are located on chromosomes, relating Genetic crosses to Meiosis.

3. **Sex Chromosomes & Sex determination –** Sex determination in Human, Drosophila & Other animals.

4. **Dosage Compensation –** Hyperactivation of X-linked genes in Male Drosophila & Inactivation of X-linked genes in Female Mammals.

5. **Rearrangements of Chromosome Number -** Polyploidy (Sterile polyploids, Fertile polyploids, Tissue-specific polyploidy & Polyteny); Aneuploidy (Trisomy, Monosomy, Deletions & Duplications of Chromosome segments), Aneuploidy is a Gain or Loss of individual chromosomes.

6. **Rearrangements of Chromosome Structure –** Inversions, Translocations, Compound Chromosomes & Robertsonian Translocations.

7. **Cytological Techniques of Chromosome analysis –** Analysis of Mitotic Chromosomes, Human Karyotype, Cyto-Genetic variation.

8. **Molecular structure of Prokaryotic Chromosome –** Chromosome structure in Prokaryotes & Viruses, Prokaryotic chromosome is packed into small space, Chromosomes of Prokaryotes are highly coiled.

9. **Molecular structure of Eukaryotic Chromosome –** Chromosome structure in Eukaryotes, Chemical composition of Eukaryotic Chromosomes, One large DNA molecule per Chromosome, 3 levels of DNA packaging in Eukaryotic Chromosomes, Centromeres & Telomeres, Eukaryotic DNA has Repetitive sequences, Structure of chromosome changes during the Cell cycle, Eukaryotic chromosome has Specialized sequences, Lampbrush chromosome, Polytene chromosome.

10. **Unique aspects of Eukaryotic Chromosome Replication –** Eukaryotic DNA Replication, DNA Polymerases in Eukaryotic cells, Nucleosome assembly.

11. **Chromosome Mutations –** Nature of Mutation, Causes of Mutation, Study of Mutations, DNA repair.

12. **Recombination & Transposable Elements –** Homologous recombination utilizes sequence complementarity, Generalized & Site-specific recombinations, Transposable elements are ubiquitous, Genomic instability caused by Transposable elements, Bacterial Transposable elements, Eukaryotic Transposable elements, Biological significance of Recombination & Transposable elements.

13. **Genetic Mapping in Prokaryotes & Eukaryotes –** Linkage maps, Linkage & Recombination between two genes & three genes, Physical Chromosome Mapping, Linkage analysis using Chi-square test, Accounting for unseen multiple crossovers.

14. **Genetic Mapping in Human Pedigrees –** Assessment of linkage in Human pedigrees using Lod scores.

15. **Molecular Organization of Chromosomes –** Genome size & Evolutionary Complexity; C-value paradox; Supercoiling of DNA; Polytene Chromosome; Unique & Repetitive Nucleotide sequences in Eukaryotic Genomes; Molecular structure of Centromere; Molecular structure of Telomere.

References :

1) **Daniel L. Hartl & Elizabeth W. Jones : Genetics – analysis of Genes & Genomes**
2) **Alan G. Atherly, Jack R. Girton & John F. McDonald : The Science of Genetics**
3) **Benjamin A. Pierce : genetics – a conceptual approach**
4) **D. Peter Snustad & Michael J. Simmons : Principles of Genetics**
5) **Tom Strachan & Andrew P. Read : Human Molecular Genetics**

MSGEN-104 : Genetics of Organelles

1. **Organelle Chromosome –** Genetic material of organelle, Leaf variegation in plants, Antibiotic Resistance in *Chlamydomonas*, Metabolic defects in *Yeast*,

2. **Organelle Heredity –** Endosymbiont Theory**,** Genetic codes of Organelles, Respiration-defective Mitochondrial mutants, Cytoplasmic Male sterility in Plants, Cytoplasmic transmission of Symbionts.

3. **Evolutionary Origin of Organelles –** Origin & evolution of Mitochondria & Chloroplasts, Eukaryotic organelles as Endosymbionts,

4. **Genetics of Cytoplasmic Transmission –** Expression of Mitochondrial genes, Interplay between Mitochondrial & Nuclear gene products,

5. **Patterns of Extranuclear inheritance –** Uniparental inheritance, Maternal inheritance & Maternal effects, Maternal effect in Snail Shell coiling, Heteroplasmy, Paternal inheritance.

6. **Biology of Mitochondria & Chloroplasts –** Biology of Mitochondria & Chloroplasts, Mitochondrial DNA, Chloroplast DNA.

7. **Mitochondrial Genome –** Origin of Mitochondrial Genome - Yeast & Human mtDNA, Mitochondrial genes; Replication, Transcription & Translation of mtDNA, Unique Human Mitochondrial Genetic Code; Comparison of Mitochondrial Genome with Nuclear Genome; Mitochondrial DNA phylogenies; Evolution of Mitochondrial genome.

8. **Chloroplast Genome –** Chloroplast biogenesis, Structure & Organization of Chloroplast cpDNA, Replication, Transcription & Translation of cpDNA, Evolution of cpDNA, Genome comparisons.

9. **Intergenomic exchange of Genetic Information –** Comparison of nuclear Eukaryotic, Eubacterial, Mitochondrial & Chloroplast genomes, Promiscuous DNA.

10. **Mitochondrial DNA & Aging in Human –** Mechanism of age-related increase in mtDNA damage, Decline of Oxydative phosphorylation capacity with age, Late onset degenerative diseases.

11. **Tracing Human History through Mitochondrial DNA –** To study Human evolution using mtDNA.

12. **Human Mitochondrial Mapping –** Human Mitochondrial genome, mtDNA & Human disease, non-universal codons in mtDNA.

References :

1) **Daniel L. Hartl & Elizabeth W. Jones : Genetics – analysis of Genes & Genomes**
2) **Benjamin A. Pierce : genetics – a conceptual approach**
3) **D. Peter Snustad & Michael J. Simmons : Principles of Genetics**
4) **Tom Strachan & Andrew P. Read : Human Molecular Genetics**

MSGEN-105 : Biophysics & Biochemistry

Topics : Biophysics

1. **Molecular Modeling & Molecular Dynamics –** Modeling of Macromolecules, different types of interaction energy, molecular potential, bonding potential, non-bonding potential, potential due to angle, torsional strain, electrostatic interaction, molecular structure of protein, lipid, nucleic acid, carbohydrate, energy minimization (SD, ABNR), molecular dynamics simulation for simple molecules (GROMACS software)

2. **Method of determination of size & shape of macromolecules –** Molecular electron microscopy, measuring electron diffraction of a solid with Electron Microscope, determination of molecular structure in Electron Microscope, minimizing drying & shrinking artifacts, using symmetry to enhance the Electron Microscope image, High Resolution Autoradiography, X-Ray diffraction

3. **Absorption Spectroscopy –** Absorption spectroscopy of electronic states, Extinction co-efficient, Spectral properties of a simple molecule (Formaldehyde), Peptide group domination of far UV absorption for

proteins, Aromatic amino acid domination of near UV absorption for proteins, estimation of protein concentration from UV absorbance, nucleic acid absorption dominated by bases.

4. **Infrared Spectroscopy –** Principles of IR spectroscopy, vibrational spectra of biopolymers, Fourier transform of Infra Red spectroscopy, Instrumentation, factors influencing vibrational frequency (Vibronic coupling, H-bond, electronic factors, bond angles, etc)

5. **NMR Spectroscopy –** Proton magnetic resonance spectra of proteins, 13C NMR spectra of proteins, 31P NMR studies, NMR spectra of nucleic acids, Fourier transform of NMR spectroscopy, Relaxation (ID spectra)

6. **X-Ray Crystallography –** Instrumentation, Fourier transformation, Application

References :

(1) Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)
(2) A. Lehninger : Principles of Biochemistry

Topics : Biochemistry

1. **Biomolecules – structure, function & metabolism –** Organization & Composition of Eukaryotic Cells; Integration & Control of Cellular functions, Structural components of Nucleic acids, higher order DNA structure, DNA sequence & function, functional roles of Proteins in Human, Amino acid composition of Proteins, higher levels of Protein organization, dynamic aspects of Protein structure & Protein stability, Methods for characterization, purification & study of Protein structure & organization, Bioenergetics & Oxidative metabolism.

7. **Mechanism of Enzyme action –** Introduction to Enzymes, How Enzymes work, Enzymes are highly powerful specific catalysts, Michaelis-Menten Model, Enzyme Kinetics as an approach to understanding mechanism, Enzymatic reactions, Regulatory Enzymes

8. **Metabolism, Pathways & Regulation –** Carbohydrate metabolism – major metabolic pathways & their control, special pathways & Glycoconjugates, Lipid metabolism – utilization & storage of energy in lipid form, metabolic pathways of special lipids, Amino acid metabolism, Purine & Pyrimidine nucleotide metabolism, metabolic interrelationships

9. **Physiological Processes –** Biochemistry of Polypeptide & Steroid Hormones, Hormones & their receptors, Regulatory cascades, Insulin & related Growth-regulating hormones

10. **Expression & Transmission of Genetic information –** Genetic control of Enzyme synthesis, Control of Gene expression, Gene expression in Prokaryotes & Eukaryotes, Response to environmental changes – Sensory systems & Immune systems

11. **Biochemical Genetics, In born Errors of Metabolism & Gene Therapy –** Metabolic pathways, Overview of the metabolic basis of inherited diseases

12. **Signal Transduction pathways –** Molecular circuits, Seven transmembrane-Helix receptors, G proteins, defects in signaling pathways which lead to Cancer & other diseases

References :

(1) Jeremy M. Berg, John L. Tymoczko & Lubert Stryer : Biochemistry
(2) Lehninger – David L. Nelson & Michael M. Cox : Principles of Biochemistry
(3) David E Metzler : Biochemistry – The Chemical Reactions of Living Cells
(4) Thomas M. Devlin : Biochemistry with Clinical Correlations
(5) Charles Rscriver, Arthur L. Beaudet, William S. Sly & David Valle : The Metabolic basis of inherited diseases

Syllabus for two-year
M.Sc COURSE **in**
Genetic Engineering
PRACTICAL PAPERS

MSGEN-106 : Microscopy & Instrumentation

1. Microscopy & Imaging
2. Principles & Operation of General Equipment usually used in Research laboratories

References :

(1) Barch M J et al; The AGT Cytogenetics Laboratory Manual; 3rd Ed, 1997; Lippincott-Raven; New York
(2) Celis Julio; Cell Biology – a laboratory manual; AP; 2nd Ed, 1998.

MSGEN-107 : Molecular Biology – Basic Techniques

1. DNA analysis (Microbes / Plants / Animal / Human)
2. Mutation detection by PCR analysis

References :

(1) Sambrook & Russell : Molecular Cloning; 3rd Ed; 2001

MSGEN-108 : Basic Cyto-Genetics Techniques

(1) Basic principles of Cyto-Genetics procedures
(2) Setting up Laboratory
(3) Peripheral Blood Cyto-Genetics Methods
(4) Chromosome staining
(5) Microscopy & Imaging
(6) Chromosome analysis & Karyotype reporting
(7) Interpretation & Recommendations in Abnormal Chromosome study
(8) Chromosomal syndromes identification & Karyotyping

References :

(1) Barch M J et al; The AGT Cytogenetics Laboratory Manual; 3rd Ed, 1997; Lippincott-Raven; New York
(2) Purandare Hema & Chakravarty Amit : Human Cyto-Genetics Techniques & Clinical Applications; 2000; Bhalani Publishing House; Mumbai

MSGEN-109 : Cell Culture Techniques (Plant & Animal)

1. General procedure for Tissue culture
2. Primary Cultures from Embryonic Tissue
3. Culture of specific Cell types
4. Cell separation techniques
5. Cytotoxic & Cell Growth Assays

References :

(1) Celis Julio; Cell Biology – a laboratory manual; AP; 2nd Ed, 1998.
(2) Culture of Animal Cells – a manual of basic techniques : R Ian Freshney (Wiley Publication)

MSGEN-110 : Biophysical & Biochemical Techniques

1. Determination of pH of unknown solution
2. Verification of Lambert-Beer's Law
3. Determination of Molecular weight of Protein by Column chromatography
4. Iso-electric focusing
5. Determination of Surface Tension by Stalagmometer
6. Determination of Viscosity by Oswald's Viscometer

References :

(1) Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)
(2) Jeremy M. Berg, John L. Tymoczko & Lubert Stryer : Biochemistry
(3) David E Metzler : Biochemistry – The Chemical Reactions of Living Cells

MSc (Genetic Engineering) - SECOND SEMESTER

THEORETICAL PAPERS

MSGEN-201 : Principles of Microbiology

1. Overview of history of Microbiology - Biogenesis and abiogenesis, Contributions of Redi, Spallanzani, Needham, Pasteur, Tyndal, Joseph Lister, Koch [Germ Theory], Edward Jenner and Flemming [Penicillin], Scope of Microbiology. **(1 Period)**

2. Microbial diversity - Whittaker's five kingdom classification of living system Systems of classification, Classification on the basis of Nutritional types, oxygen requirement, Cell morphology, function, reproduction, Definitions & Examples of Photosynthetic eubacteria (cyanobacteria), Gliding bacteria (Myxobacteria and Cytophaga group),Gram negative eubacteria (Spirochetes, Rickttsias, Chlamydias), Gram positive eubacteria (Actinomycetes), Spore forming bacteria (spore formation and germination), Fermentative bacteria – metabolic character, Nitrogen fixing bacteria, The mollicutes. **(2 Periods)**

3. Brief description of Eukaryotic Algae & Fungi and Protozoa : General characteristics, vegetative & reproductive structure of Algae (Cyanophyta, Cholorophyta, Bacillariophyta, Phacophyta, Rhodophyta), Fungi (Phycomycetis, Bacidiomycetis, Zygomyetes, Oomycets, Asomycetes, Deuteromycetes -imperfect and perfect stages), Protozoa (*Giardia, Entamoeba* and *Plasmodium*).
(2 Periods)

4. Structure and function of Prokaryotic cell & its components - The Slime and the cell wall of bacteria containing peptidoglycan and related molecules; the outer membrane of Gram-negative bacteria, the cytoplasmic membrane, mesosomes, flagella, Pilus, fimbriae, ribosomes, carboxysomes, sulfur granules, glycogen, polyphosphate bodies, fat bodies, gas vesicles; endospores, exospores, cysts, Mycelia of fungi and Actinomycetes, Cytoskeleton filament, heterocysts and akinets of Cyanobacteria, Gliding and motility. **(2 Periods)**

5. Microbes in Extreme Environment – Nature, special features of the thermophilic, methanogenic and halophilic Archaea; photosynthetic bacteria, some Archaea who live in extreme conditions like cold, and space.
(1 Period)

6. Basic concepts of Virology - General characteristics of viruses, differences between bacteria and viruses, Classification of viruses Physical and chemical Structures of different Viruses on the basis of capsid symmetry - enveloped (Herpes virus), helical (TMV), icosahedral (Polyoma viruses) and complex (Bacteriophage, and Virion size, General Properties of Viroids & Prions, Filamentous DNA phages, Single stranded RNA phages, Cauliflower Mosaic, Virus of Plants; HIV, Vaccinia and Simian virus of animals, Insect virus.
(3 Periods)

7. Kinetics of Bacterial Growth : Different types of bacterial culture (Batch, Synchronous, Arithmatic) – Definition and brief description. Growth Phases, Growth Kinetics, Calculation of duration of Phases and generation time, Growth yields, Methods of growth determination, Environmental factors affecting growth - temperature, pH, osmotic pressure and nutrient concentration per cell.
(2 Periods)

8. Microbial Metabolism - Biological N_2-fixation, Free living N_2-fixation by anaerobic (*Clostridium*), facultatively anaerobic (*Azospirillum*) and aerobic (*Azotobacter*), N_2-fixers associated with stem, root and leaf, Symbiotic N_2-fixation in legumes and non- legumes by *Rhizobium* and *Frankia*, N_2-fixation by cyanobateria. Requirement of ATP, O_2-sensitivity and inhibition by ammonia and nitrogenous substance in the case of

nitrogenase, The peculiarity of alternate nitrogenase of *Streptomyces t**hermoautotrophicus,* genetics and regulation of N2 fixation, . **(2 Periods)**

9. Photophosphorylation – Conversion of light energy into chemical bond energy. Role of bacterio-chlorophyll in photosynthetic bacteria and cholorphylls in green algae. The role of phycocyanin, phycoerythrin and carotenoids. Photosystems I & II. Production of ATP by Cyclic phosphorylation in photosynthetic bacteria and both cyclic and non-cyclic phosphorylation in Cyano-bacteria and green algae. Photosynthesis in anerobic and sulphur bacteria. **(2 Periods)**

10. The reduction of CO_2 – Reverse citric acid cycle and hydroxypropionate cycle. The reduction of CO_2 by Calvin cycle. The Production of 4-, 5-, 6-, and 7- carbon sugars. CO_2 Fixation by chemolithotrophs under aerobic condition by nitrifying bacteria, Oxidation of methane by methanotrophs.
(2 Periods)

11. Prokaryotic Genomes - Genetic organization of prokaryotic genomes (E. coli genome, Genome of other bacteria, Genome of other Archaea); Physical organization of bacterial genomes (Structure of the bacterial nucleoid, Replication and partitioning of the bacterial genome); Plasmid (Different types of plasmids, Plasmid and bacterial sex, Copy number and incompatibility).
(2 Periods)

12. Genetics of Bacteria and their Viruses - Bacterial transposons, Mobile DNA (F Plasmid : a Conjugate plasmid, Insertion sequence and transposons, Mobilization of Nonconjugative plasmid, Integrons and Antibiotic-Resistance cassettes, Multiple Antibiotic Resistant bacteria); Bacterial Genetics (Mutant phenotype, Mechanism of genetic exchange); DNA mediated Transformation; Conjugation (Cointegrate Formation and Hfr Cells, Time–of–Entry Mapping, F' Plasmid); Transduction (The Phage Lytic cycle); Generalized transduction, Specialized Transduction). **(3 Periods)**

13. Bacteriophage Genetics - E.coli PhageT4, E.coli Phage T7, E.coli phage lambda, Immunity to infection, Prophage integration, Induction of prophage, Induction & Prophage excision, Repressor, Structure of the operator and binding of the repressor and the Cro product, Decision between the lytic and lysogenic Cycles, Transducing phages, E.coli phage phiX174, filamentous DNA phages, Single stranded RNA phages, Benzer's fine structure of gene in bacteriophage T4 : Plaque Formation and Phage Mutants, Genetic recombition in the lytic cycle, (concept of recon, muton, cistron). **(3 Periods)**

14. Food Microbiology - Microbiology of milk, Cheese, Yogurt (curd), Idli, Spoilage of food (fresh and cooked, canned food, Vegetables, fruits, fish, poultry product, meat and meat products, a brief account on common food–borne infections and toxicoses (Salmonellosis, Botulism, Cholera, Mycotoxicosis, *E.coli* –poisoning). A brief account on Food preservation (pasteurization, appertization, aseptic packaging; use of high temperatures, freezing, dehydration, ionizing radiation, osmotic pressure; use of chemicals - organic acids, esters, sulphur-dioxide, salts and high sugar concentration - sweets etc.). **(2 Periods)**

15. Agricultural Microbiology - Soil as microenvironment, Soil pores and movement of gases for microbial activity, Microbes in soil surface and different zones of soil, Decomposition of Plant and animal residues by microorganisms in soil, Brief account of microbial interactions (Symbiosis**,** neutralism, Commensalism, Competition, Ammensalism, Synergism, Parasitism), Biofertilizers- Biological Nitrogen fixation- symbiotic and asymbiotic, mass production by *Rhizobium*, *Azotobacter* and Cyanobacteria, nitrifying ammonifying and photosynthetic bacteria, Denitrification of nitrate fertilizers to N_2 and N_2O (a green house gas) by denitrifying bacteria, free living and in association with *Azolla*, Phosphate solubilizing bacteria. Soil anerobic methanogens in rice field, Biological control of soil-borne microbial pathogens and nematodes - Microbial pesticides, interaction of synthetic pesticides with soil microorganisms, Entomopathogenic Fungi, Effect of soil pH and heavy metals on microorganisms, Microbial antagonism in soil, Role of soil protozoa, nematodes and fungi. **(3 Periods)**

16. Industrial Microbiology - Biomining and bioleaching of ores (Use of thermophilic microorganisms in industrial microbiology, Retting of jute, Biogas production, Biologics for immunization (Production of monoclonal antibodies), Deterioration of paper, textiles, painted surfaces and their prevention, Biofilms, microbial biopolymers, biosurfactants, Petroleum prospecting and formation of oil spills, Microbial culture selection with high yield potential, Strain preservation, maintenance and strain improvement by mutation of gene transfer

processes, Batch, fed-batch and continuous cultures (definition and kinetics), Fermenters (Stirred tank, bubble columns, airlift. Bioreactors, Static, Submerged and agitated fermentation), Use of immobilized cells and enzymes (Ca-alginate beads, polyacrylamide); Industrial production of Ethyl alcohol, Acetic Acid (Vinegar), Citric acid, lactic acid, α-amylase, protease penicillin, tetracycline and vitamin $B_{12,}$ with reference to easily available raw materials, inoculum, type of reactors, recovery and purification, Production of herbal drugs. **(3 Periods)**

17. **Medical Microbiology -** Normal microbial population of healthy human body (Skin, mouth, upper respiratory tract, intestinal tract, urino-genital tract, eye), Harmful Microbial Interactions with Human (Entry of pathogens into the host, types of bacterial pathogens, Mechanism of bacterial pathogenicity, colonization and growth, Virulence, Virulence factors – exotoxins, enterotoxins, endotoxins, neurotoxins. – avoidance of host defense mechanisms, damage to host cell, Host factors for infection and innate resistance to infection), **(2 Periods)**

18. **General Account of Epidemiology -** Principles of epidemiology, Current epidemics (AIDS, Nosocomical, Acute respiratory Syndrome), Measures for prevention of epidemics – Global health consideration, Emerging and reemerging infectious diseases, Biological warfare and biological weapons, Person to person Microbial disease (Names of pathogen, disease symptoms, and preventive measures), Direct contact transmission of diseases (*Staphylococcus*, *Helicobactor pylori* and Gastric ulcers, Hepatitis viruses), Sexually transmitted diseases (Gonorrhea and syphilis, AIDS and HIV), Animal transmitted diseases (Rabies, Hantavirus pulmonary syndrome), Arthropod transmitted disease (Rickettsia, Malaria, Plague), Soil borne diseases (Tetanus), Water borne microbial diseases (Cholera, Typhoid, Amoebiasis, Giardiasis). **(3 Periods)**

19. **Chemical control of Pathogens** – Definition and Classification of antibiotics on the basis of structure and mode of action, Assay of antibiotics, antibiotic spectrum Naturally produced drugs, Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy, Semi-synthetic antibiotic, Sulfar drugs - their use and mechanism of action, Nalidixic acid, nitrofurans, isonicotinic hydrazide, metronidazole; Prophylactic agents, Drug toxicity, Drug resistance – chromosomal mutation and plasmid-borne multiple drug resistance, Cyclic polypeptide antibiotics of bacteria. **(2 Periods)**

MSGEN-202 : Genetics of Model Organisms

1. **The content of our genome:** Eukaryotic genomes contain both non repetitive and repetitive DNA sequences, Human genome has fewer genes than expected Genomes can be mapped by linkage, restriction cleavage or DNA sequence, RFLPs and SNPs for genetic mapping. **(5 Periods)**

2. **Genomes -** types of genomes, genomes & genetic variation, comparison of different genomes, genome evolution. **(3 Periods)**

3. **Genomics –** about the genomics, history, comparative genomics, comparative genomic hybridization, functional genomics. **(3 Periods)**

4. **Human Genome Project (HGP) –** an overview of the project, goals of the project, major scientific strategies & approaches used in HGP, expected scientific & medical benefits of this project, about the organizations behind this project, an overview of projects of other model organisms of Human Genome Project. **(4 Periods)**

5. **HGP & its impact –** impact of Human Genome project in Plant, Animal & Human. **(3 Periods)**

6. **Biology & Life cycles –** study of biology & life cycles of model organisms (E. *coli*, Yeast, *Arabidopsis thaliana*, C. *elegans*, *Drosophila melanogaster*, laboratory mouse, Zebra fish & Human). **(8 Periods)**

7. **Genomics of selected Genomes –** about genomics of model organisms (E. *coli*, Yeast, *Arabidopsis thaliana*, C. *elegans*, *Drosophila melanogaster*, laboratory mouse, Zebra fish, Human). **(8 Periods)**

8. **How Human genome was mapped –** physical mapping, genetic mapping, gene ontology, gene annotation. **(3 Periods)**

9. **Technologies used in HGP –** RFLP, microsatellite markers, STS, EST, DNA sequencing, DNA microarray. **(5 Periods)**

MSGEN-203 : Principles of Molecular Cell Biology

1. Recombinant DNA Technology and Molecular Cloning –

(a) How to clone a gene - What is clone, Overview of the procedure, Gene library, Hybridization, molecular cloning, construction of DNA library, Library screening, Expression libraries, Restriction mapping, RFLP, DNA sequencing. **(2 Periods)**

(b) Purification and Separation of nucleic acids – Extraction and Purification of nucleic acids, Detection and Quantitation of Nucleic acids, Gel Electrophoresis. **(1 Period)**

(c) Cutting and Joining DNA – Restriction Endonucleases, Ligation, Alkaline Phosphate, Double Digest, Modification of Restriction Fragments ends, Other Ways of joining DNA Molecules. **(1 Period)**

(d) Vectors – Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, Expression vectors, Vectors for cloning and expression in Eukaryotic cells, Super vectors : YACs and BACs. **(1 Period)**

(e) Amplifying DNA : PCR and Cell based DNA Cloning – The importance of DNA Cloning, PCR : basic features and application, Principles of Cell-based DNA Cloning, Cloning System for amplifying different sized fragments, Cloning System for producing single-stranded and mutagenized DNA. **(2 Periods)**

(f) Nucleic Acid Hybridization : Principle and application - Preparation of nucleic acid probes, Principle of Nucleic acid hybridization, Nucleic acid hybridization assays, and microarrays. **(2 Periods)**

(g) Gene Recombination and Gene transfer : Bacterial Conjugation, Transformation, Transduction, Episomes, Plasmids, Microinjection, Electroporation, Microprojectile, Shot Gun method, Ultrasonication, Liposome fusion, Microlaser. **(2 Periods)**

(h) Changing genes: site-directed mutagenesis and Protein engineering: Primer extension is a simple method for site directed mutation, PCR based site directed mutagenesis, Random mutagenesis, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins. **(2 Periods)**

2. Tools for analyzing gene expression -

(a) Reporter Genes – Commonly used reporter genes, Analysis of gene regulation Purification and detection tags. **(1 Period)**

(b) Analysis at the level of gene transcription – Northern blot, in situ hybridization, Rnase protection assay, RT-PCR. **(2 Period)**

(c) Analysis at the level of Translation – Western blot, in situ analysis, ELISA, protein gel electrophoresis, Antibody production. **(2 Periods)**

MSGEN-204 : Genetic Biodiversity and Taxonomy

1. **Basic concept of Biodiversity –** What is Biodiversity, Why should we conserve it, Elements of Biodiversity - Ecosystem Diversity, Genetic Diversity, Species Abundance & Diversity, Patterns of Species Diversity. **(5 Periods)**

2. **Global patterns of Biodiversity –** measuring biodiversity, Cataloging and Discovering Species, Geographical Patterns of Species Richness, Biogeography, Importance of Distribution Patterns (Local Endemics, Sparsely Distributed Species, Migratory Species), GAP Analysis. **(6 Periods)**

3. **Biodiversity & Conservation –** Overexploitation threatening living species**,** International Trade, Animals threatened by International trade, Problems in Controlling International Trade (Enforcement, Reservations, Illegal Trade), Free Trade & the Environment, Free Trade & Conservation, Common patterns of Overexploitation. **(6 Periods)**

4. **Exotic Species –** Plants, Invertebrates, Fishes, Amphibians, Reptiles, Birds, Mammals, Detrimental Effects of Exotic Species. **(3 Periods)**

5. **Endangered Species Conservation –** The US Endangered Species Act, State Endangered Species Acts Successes and Failures of the Endangered Species Act Role of ESA in Habitat Protection, Critical Habitat, Problems with the Endangered Species Act, Habitat Conservation Plans. **(5 Periods)**

6. **Ethics of Conservation –** Values of Biodiversity, Biopiracy, Hybridized plants, GM crops (benefits & criticism), Economic Value of Biodiversity & Legal, Ethical and Conservation issues related to uses of biodiversity, Global Conservation Issues. **(4 Periods)**

7. **Human Population Growth –** Carrying capacity of the Earth, Primary productivity of the Earth, Regional Differences in Population Problems, Regional Differences in Population Density and Growth Rate, Age Structures and the Demographic Transition, Effects of Uneven Income Distribution. **(3 Periods)**

8. **Basic concept of Taxonomy –** Names and Naming: Essentials of Nomenclature, Classification, Construction of Phylogenetic tree, Systematics, Cladistics, Cladograms, Phenetics. **(7 Periods)**

9. **Molecular phylogenies –** Immunological techniques, Amino acid sequences, Quantitative DNA measurements, Repetitive DNA sequences, Nucleic acid phylogenies based on: DNA-DNA hybridizations, Restriction Enzyme sites & Nucleotide sequence comparisons and homologies, Combined Nucleic acid-Amino acid phylogenies, rates of Molecular change: Evolutionary Clocks, Regulatory genes & some Evolutionary consequences. **(6 Periods)**

10. **Taxonomy in relation to Chromosomal morphology & Evolution –** Chromosomal evolution, why location of genes matter, evolutionary oddities about chromosomes, evolutionary effect of rearrangements of chromosomes, karyotypic orthoselection, chromosomal evolution & speciation. **(6 Periods)**

11. **Molecular Taxonomy in relation to DNA characteristics & Protein sequences –** modes of molecular evolution, Neutral theory of Molecular evolution, genetic markers for taxonomic purposes, comparing total genome by DNA-DNA hybridization, comparing DNA sequences, Cladistics, biological identification through DNA barcodes, chromosome painting, establishing molecular homology using protein sequences. **(8 Periods)**

MSGEN-205 : Quantitative Analysis

Mathematics:-

1. Differentiation: (Function of single variable)

Derivative & its geometrical significance, algebra of differentiation (without derivation), monotonic function, extrema of function, application in chemistry. **(5 Periods)**

2. **Differentiation: (Function of two variables or more)**
   Partial differentiation, Homogeneous function & Euler's Theorem, exact and inexact differentiation with specific emphasis on thermodynamic properties. **(5 Periods)**

3. **Integration:**
   Basic rules of integration (without derivations), Definite & indefinite integrals, Geometrical meaning of integration, application in Biology & chemistry. **(5 Periods)**

4. **Differential Equation:**
   Separation of variables, Homogeneous-, extract- & ordinary linear differential equations, Second order linear differential equations, application of differential equation in chemistry & biology.
   (5 Periods)

Probability & Statistics: -

5. **Probability: -**
   Definition of Probability, Relative frequency, Probability distribution (Binomial, Poisson & normal), simple examples. **(5 Periods)**

6. **Statistics: -**
   Measure of central tendency – Mean (for grouped & ungrouped data);
   Measure of dispersion- Standard Deviation (for grouped & Ungrouped data);
   Sampling theory –Statistical population, Sample from population, Random sample;
   Statistical Hypothesis - Test of significance, Test for proportion, means & standard deviations, Chi-square test of goodness of fit, t-test, F-test.
   Correlation & Regression (linear) - Associated test of significance, simple problems. **(5 Periods)**

Computer Application :-

7. **The Concept Of Information System:** The information society, Properties of Information, Data, Approaches of Information. Types of Information Flow, Scope of Information. Concept of Information System, Types of Information System. Data Flow Diagrams, Flowcharts. Data Processing Approach, File Server System, Client Server System.
   (2 Periods)
8. **The Internet:** Basic Concept of Internet, www, Internet Protocol, TCP/IP, Hosts, Hyper-link, Browsers, Connection access, Gopher , Netscape, FTP Server, Remote Login & Telnet, Search Engine, Electronic Mail.
   (1 Periods)
9. **Hardware and Software:** Evolution of Computers, Memory System , Various devices, High Input /Out put Organization, I/O processors, Parallel Organization, Pipelining. Concept and Types of Software, Categories Of Language, Operating System, Serial and Batch Processing. Types Of Operating System, Graphical User Interface, Brief Concept of Software Development. Data Communications, Network Concept, WAN, LAN, ISDN, NICNET, I- Net. Computer Security & Virus , Risk Analysis, Backup, Branches and Measures Of Security, Types of Security, Computer Virus, The MENACE, Classification and Types of Virus, Pretension and Cure. **(4 Periods)**
10. **Office Automation Applications:** Office Systems, Telecommunicating Centers, Cyberspace, D.M.A, DBMS, Using DBMS, ACCESS as DBMS. Nature of Computer Applications, Reports, Payroll, File Systems, Multimedia Application: Concept on Multimedia, Hardware Requirements, Software for Multimedia used in Biological Science, Components of Graphics, Application Of Multimedia, Learning Environment, Authoring Software & tools, Quick Time, Director X, Applications Of Hypertext, Elements of Hypertexts, Creating Web Pages, Server Concept, HTML. **(3 Periods)**

11. **Large Public Service Applications and Basic Tools For Bioinformatics:**
    Biological Research on Web: Using search engines, finding scientific Articles, Pub med search, Searching biological database, PDB, Database & Visualization: Basic Ideas of FASTA & BLAST, Applying perl bioinformatics, Application of database software in bioinformatics.
    (2 Periods)

MSc (Genetic Engineering) - SECOND SEMESTER

PRACTICAL PAPERS

MSGEN-206 : Microbiological Techniques

1. Sampling and quantification of microorganisms in air, soil and water.

2. Methods of inoculation of different microbes in selective media.
   Isolation of bacteria [Streak plate, spread plate, pour plate, serial dilution]

3. Identification of microorganisms from the habitats [simple staining, differential staining, acid fast staining, capsule staining, spore staining and motility]
   Observation of morphology - shape and arrangement of cells.

4. Microscopic measurements, micrometer (ocular and stage), haemocytometer.

5. Microscopic study of phytoplanktons & zooplanktons.

6. Preparation of Yoghurt.

7. Citric acid production, its recovery and purification (lab scale)

8. Isolation and enumeration of phosphate solubilising, cellulose decomposing and starch hydrolising bacteria from different habitats (plate count method).

9. Determination of potability of water following MPN methods. Presumptive and confirmatory tests of coliforms.

10. Isolation of symbiotic N_2-fixing bacteria from root nodules from leguminous plants.

11. Isolation of Auxotrophic / Antibiotic Resistant mutant by Induced mutagenesis in Bacteria by Replica plating technique.

12. Preparation of Baker's Yeast from molasses.

MSGEN-207 : Life Cycle Studies (Model organisms)

1. **E. coli** - Life cycle study, isolation & identification of mutants.

2. **Yeast** – Life cycle study, isolation & identification of mutants.

3. **Drosophila** - Life cycle study, isolation & identification of mutants.

4. **Zebra fish** - Life cycle study, isolation & identification of mutants.

5. **Laboratory Mouse** - Life cycle study, isolation & identification of mutants.

MSGEN-208 : Genetic Engineering Tools- I

1. Transformation in E. coli DH5□

2. Bacterial conjugation

3. Phage Titration
4. Plasmid preparation
5. Restriction enzyme digestion
6. Ligation
7. DNA molecular size determination
8. Bacterial Antibiotic sensitivity
9. Bacterial gene expression (using Lac promoter system)

MSGEN-209 : Genetic Toxicity Testing

1. Short-Term Biochemical Tests for Genetic Toxicity
2. Test for gene mutations in bacteria - Bacterial Reverse Mutation Test
3. *in vitro / in vivo* test with cytogenetic evaluation of chromosomal damage (Chromosomal Aberration Test) using mammalian (Lab. Mouse) cells
4. Ames test

MSGEN-210 : Computer Application

1. Introduction to **Windows**.
2. **Microsoft Windows**: Windows Fundamentals, File Managing Systems, Printing in Windows, Windows Accessories.
3. **Microsoft Word**: MS Word Basics, Typing and Editing, Formatting Text, Page Design Layout, Mail-Marge, Document Management.
4. **Microsoft Excel**: Introduction, Formatting Worksheet, Customize Workplace, Calculations, Charts, Database Power of Excel.
5. **Microsoft PowerPoint:** Presentations, Graphics, Creating a Presentation, Customize a Slide Show, Editing and Saving a presentation.
6. **Image Editing Through Graphic Software and Transferring Into a Slide Presentation**.
7. **Microsoft Access:** Concept of DBMS.
8. Application of Graphics Editing Software- **Photoshop**.
9. Introduction to **Flash** and **HTML**.
10. **Programming : C**

a. Concepts of flowcharting, algorithm development, pseudo codes etc.
b. Computer assignments based on the following topics in 'C' programming:

Data types, operators and expressions, Hierarchy of operators, control statements including decision (if, if-else), loops (while, do-while, for), branching (switch, break, continue), functions, arrays (1D, 2D- all matrix operations including inverse of a matrix), strings, file handling, data structures etc.

Syllabus for two-year
M.Sc COURSE **in**
Genetic Engineering
MSc (Genetic Engineering) - THIRD SEMESTER
THEORETICAL PAPERS

MSGEN-301 : Engineering of Genes and Genomes

1. In Vivo Techniques of Genetic Manipulation
Introduction / Historical perspective / Cutting and joining DNA / Molecular Cloning / Constructing DNA libraries / Probes / Library screening / Expression libraries / Restriction mapping / RFLP / DNA sequencing / Transposons.
(8 Periods)

2. Tools for analyzing Gene Expression
Introduction / Transient and stable transfection assays / In vitro mutagenesis / Analysis at the level of gene transcriptions / RNA expression and localization / Analysis at the level of translation : protein expression and localization / Antisense technology / Analysis of DNA-Protein interactions / Structural analysis of proteins / Model organisms. **(10 Periods)**

3. Genetically Modified Organisms-use in Basic & Applied Research
Introduction / Cloning by nuclear transfer / transgenic technology / Transgenic mice / Transgenic *Drosophila* / Transgenic C *elegans* / Transgenic Zebra Fish / Transgenic Arabidopsis / Transgenic Cattle / Transgenic Chicken / Transgenic Goat / Gene-targeted Mouse models / other applications of Transgenic Animal Technology / Transgenic Plants. **(14 Periods)**

4. Genome Analysis - DNA typing, Genomics & Beyond
Introduction / DNA typing / The Human Genome Project / Other sequenced genomes / High-throughput analysis gene functions / Single Nucleotide Polymorphisms. **(6 Periods)**

5. Medical Molecular Biology
Introduction / Molecular Biology of Cancer / Gene therapy / Genes & Human Behavior
(4 Periods)

Recommended Texts & References:
1) Fundamental Molecular Biology ; Allison LA; 2007
2) Recombinant DNA, Watson et al ; 5th Ed; 2006
3) Techniques for Engineering Genes ; Curell BR et al;2004
4) Techniques for Molecular Biology ; Tagu D & Moussard C; INRA; 2006
5) Gene Cloning and DNA Analysis ; 5th Ed ; Brown TA ; 2006
6) Analysis of Genes and Genomes ; Reece RJ ; Wiley; 2004
7) Recombinant DNA and Biotechnology ; 2nd Ed ; Kreuzer H and Massey A ;ASM;2006
8) Human Genetics and Genomics ; Korf BR ; 3rd Ed ; Blackwell; 2007
9) Molecular Cloning; 3rd Ed; Sambrook & Russel : Cold Spring Harbour Laboratory press, NY ; 2001
10) ICRF Handbook of Genome Analysis ; Spurr NK , Young BD , Bryant SP;1998

MSGEN-302 : Genomics, Proteomics & Bioinformatics

Module I : GENOMICS **(14 Periods)**

Large scale genome sequencing strategies.
Genome assembly and annotation.
Prediction of Genes, Promoters, Splice sites,
Regulatory reg ions : Basic principles, application of methods to prokaryotic and eukaryotic genomes and interpretation of results.
Gene networks.
Structural Genomics (SG): the need for SG, basic principles, approaches for target selection.
Functional Genomics: application of sequence based and structure-based approaches to assignment of gene functions, e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc.

Use of various derived databases in function assignment.
DNA microarray : basic principles, using the databases, understanding of microarray data and correlation of gene expression data to biological processes and computational analysis tools (especially clustering approaches).

Module II : PROTEOMICS **(14 Periods)**

Protein arrays : basic principles; Bioinformatics-based tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); databases (such as InterPro) and analysis tools.
Protein-protein interactions: databases such as DIP, PPI server and tools for analysis of protein-protein interactions.
Identification of disease genes: basic concepts, need for identification of disease genes, Role of Bioinformatics - OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling;
Identification of SNPs, SNPs databases (DbSNP).
Metabolic pathways: databases such as KEGG, EMP.

Module III : BIOINFORMATICS **(14 Periods)**

Introduction of Genomic Data and Data Organization.
Sequence Data Bank – Introduction to sequence data banks – protein sequence data bank, NBRF -PIR, SWISSPROT, Signal peptide data bank, Nucleic acid sequence data bank -GenBank, EMBL, nucleotide sequence data bank, AIDS Virus sequence data bank, rRNA data bank.
Structural data banks – protein Data Bank (PDB).
The Cambridge Structural Database (CSD).
Genome data bank – Metabolic pathway data; Microbial and Cellular Data Banks.
Introduction to MSDN (Microbial Strain Data Network).
Numerical Coding Systems of microbes.
Hybridoma Data bank structure.
Virus Information System, Cell line information system.
Other important Data banks in the area of Biotechnology / Life Sciences / Biodiversity.
Sequence analysis – Analysis of Tools for Sequence Data Banks.
Pair-wise alignment – NEEDLEMAN and Wunsch algorithm, Smith Waterman.
Multiple alignment – CLUSTAL, PRAS; BLAST.
FASTA algorithms to analyze sequence data.
Sequence pattern, motifs and profiles.
Secondary Structure predictions;
Prediction Algorithms.
Chao -Fasman algorithm, Hidden - Markov model.

Recommended Texts:

1) T.A.Brown ; Genome 3 ;2007
2) D.W.Mount : Bioinformatics ;2nd Ed ; Cold Spring harbor Laboratory Press;2004
3) Spurr NK , Young BD , Bryant SP ;ICRF Handbook of Genome Analysis ;1998
4) Dunham I ;Genome mapping and Sequencing ; 2003
5) Meyrs RA ;Genomics and Genetics ; 2007
6) Sussman HE & Smit MA ; Genome ; Asian Ed; Cold Spring Harbor Laboratory Press;2004
7) S. B. Primrose and R. M. Twyman; *Genomics: Applications in Human Biology*
8) R. Westermeier and T. Naven: *Proteomics in Practice* (A Laboratory Manual of Proteome Analysis)
9) Branden and Tooze "Introduction to Protein Structure"
10) R. R. Sinden, "DNA Structure & Function"
11) A. R. Leach "Molecular Modelling - Principles & Function"
12) Mount "Bioinformatics" Cold Spring Harbour
13) Arthur Lesk "Introduction to Bioinformatics"

MSGEN-303 : Microbial Biotechnology

1. Principles of Microbial Biotechnology
Introduction / Microbial production of Industrial Chemicals / Microbial Fermentation / Microbial Enzymes / Transformation Processes / Design and operation of a Conventional Fermentor / Industrial Fermentor.
(4 Periods)

2. Genetic Engineering of Microorganisms
Introduction / Recombinant Microorganisms in Basic Research / Improvement of Industrial Organisms / Application of Recombinant Microorganisms in Medicine / Application of Recombinant Microorganisms in Agriculture / Application of Recombinant Microorganisms in Environmental Protection.
(5 Periods)

3. Potential Microbial Applications - Cleanup of toxic-wastes, Production of novel therapeutic and preventive agents and pathways, Energy generation and development of renewable energy sources (e.g., methane and hydrogen), Production of chemical catalysts, reagents, and enzymes to improve efficiency of industrial processes, Management of environmental carbon dioxide related to climate change, Detection of disease-causing organisms and monitoring of the safety of food and water supplies, Use of genetically altered bacteria as living sensors (biosensors) to detect harmful chemicals in soil, air, or water, Understanding of specialized systems used by microbial cells to live in natural environments with other cells. **(5 Periods)**

4. Bioconversions – Overview of Bioconversion, Enzymatic hydrolysis, Synthesis gas fermentation
(2 Periods)

5. Microorganisms and Agriculture – Classification of Soils based on their Microbiological properties (Functions of Microorganisms: Putrefaction, Fermentation, and Synthesis, Relationships Between Putrefaction, Fermentation, and Synthesis), Classification of Soils Based on the Functions of Microorganisms (Disease-Inducing Soils, Disease-Suppressive Soils, Zymogenic Soils, Synthetic Soils), Ice-Minus bacteria, Microbial pesticides, Utilization of beneficial Microorganisms in Agriculture, Controlling the Soil Microflora for Optimum Crop Production and Protection. **(4 Periods)**

6. Products from Microorganisms – Metabolites, Enzymes, Antibiotics, Fuels, Plastics
(4 Periods)

7. Bioremediation - Biotransformation of toxic wastes to harmless products, Oil-Spills, Wastewater treatment, Chemical Degradation of Heavy Metals. **(3 Periods)**

8. Oil and Mineral Recovery - Oil recovery, Metal extraction **(2 Periods)**

9. EM Technology - Effective Micro-organisms, EM-BOKASHI, EM-COMPOST, EM-5, EM-X, Recycling.
(4 Periods)

10. Patenting Microbial Biotechnology – IPR, TRIPs & Patent Law, Patenting life, Patenting Microorganisms, Patenting of Genes & DNA sequences, Microbial biopiracy. **(4 Periods)**

11. Microbial Genomics – Model Microbes, Why Microbes, Criteria for Genome Selection**,** Research by Microbes, Benefits, Microbial Genome Databases. **(5 Periods)**

Recommended Texts & References:

1. Larry Snyder and Wenndy champness ; Molecular Genetics of Bacteria ; ASM Press ; 2003
2. Channarayappa ; Moleclar Biotechnology ; 2006
3. Peppler and Periman ; Microbial technology ; 2nd Ed;Academic press; 2004
4. Barnum SR ; Biotechnology ; Indian edition ; Vikas pub.; 1998
5. Baker KH ; Bioremediation. McGraw Hill , New York
6. Murooka Y and Imanaka T ,eds ; Recombinant Microbes for Industrial and Agricultural application ; Marcel Dekker, Inc, N.Y

MSGEN (MBT)-304 : Medical Biotechnology - I

Module I : HUMAN PHYSIOLOGY **(20 Periods)**

1. Introduction - Overview of different systems of Human body.

2. Neurobiology – Neurons & Glial cells, Neuronal function (Action potential, structure & formation of synapses, Neurotransmitter transporters, receptors & signaling mechanisms), Synaptic plasticity, Sensory systems, Neural development.

3. Neurophysiology – Neurulation, Human Brain development, Neuronal migration (Radial & Tangential migration), Neural development in the adult nervous system (Neuroregeneration), Electrophysiology, Neuroscience, Brain, Neural coding, Neurology, Neuroregeneration in the Peripheral Nervous system & Central Nervous system, Neuroregeneration in diseases, Neurodegenerative diseases.

4. Cell physiology – Cellular electrophysiology, physiology of membrane transport, neuron transmission, muscle contraction.

5. Cardio-vascular physiology - The heart, Electrophysiology of the heart, Normal circulation (Cardio-vascular pressure, Heart rate & Stroke volume), Cardiac cycle, Coronary circulation, Cardiac output, Systemic circulation, Blood flow : Hagen-Poisseuille formula, Control of systemic circulation, Control of arterial pressure, Cardiovascular responses to anaesthesia**,** Clinical Determination of Mean-Cardiovascular Pressure, Arrhythmias, Cardiac Valve disease (heart murmurs), Coronary artery disease, Edema, Abnormal circulation (Heart failure, Shock, Hypertension, Arterio-venus fistula), Peripheral artery disease (Intermittent claudication).

6. Physiology of Circulatory system – Blood flow through Heart, Heart rate & stroke volume, Blood pressure, changes occur to the mammalian fetus after birth.

7. Gastro-intestinal physiology – Methods of feeding, functions of different parts of alimentary system, types of Endocrine & Exocrine secretions, Gastric hormones, Anabolism & Catabolism, Metabolic rates.

8. Respiratory Physiology – Respiratory Volumes (lung volumes, vital capacity, functional residual capacity, dead space, spirometry, body plethysmography, peak flow meter), Mechanics of Respiration, Circulation, Ventilation & Perfusion (pulmonary circulation, positive pressure ventilation, hypoxic vasoconstriction, ventilation (physiology), perfusion, ventilation/perfusion ratio(V/Q), and ventilation/perfusion scan, shunts: right-to-left (tetralogy of fallot), left-to-right (patent ductus arteriosus), respiratory rate and respirometer), Transport of respiratory gases (O2 & CO2), gas exchange, Dalton's law, oxygen-haemoglobin dissociation curve, Bohr effect, Haldane effect, carbonic anhydrase, oxyhemoglobin, respiratory quotient, arterial blood gas, Control & Response (control of respiration, reticular formation, pons (apneuistic and pneumotaxic), chemoreceptors (medulla, carotid body, aortic body), Hering-Breuer reflex, involuntary control of respiration, exercise, hyperoxia, hypoxemia (hypoxic hypoxia), Disorders (altitude sickness, asthma, carbon monoxide poisoning, COPD, emphysema, infant respiratory distress syndrome, pulmonary edema)

9. Renal physiology – Functions of Kidney (regulation of pH, secretion of Hormones, Extracellular Homeostasis), production of Urine, Mechanisms of Filtration (Renal Plasma threshold), Mechanisms of Reabsorption (Indirect reabsorption & Secretion), measurement of Renal function.

10. Endocrinal physiology - Function of endocrine organs, hormones and receptors, Chemical classes of hormones, Amines Peptide Steroid, Neuro-endocrinology, Reproductive endocrinology.

11. Reproductive physiology – physiology of male and female reproductive system, role of the endocrine system in the control and maintenance of reproduction, Andrology, Gynaecology, Ovulatory mechanism, Ovarian cycle, Pituitary & Ovarian hormones, Physiology of Conception & Prenatal Development, Causes of Infertility.

12. Physiology of Musculo-Skeletal system - Muscle Energetics, Muscle metabolism during exercise, Neural Control of Skeletal Muscle, functions of Smooth & Cardiac muscles, Fatigue, Rigor mortis.

13. Pathophysiology – Dermatopathology, Immunodermatology, physiology of Skin (skin layers & components, functions, variability in skin tone, diseases) & Hair (types of Hair, Growth, texture, aging and pathological impacts on Hair)

Module II : HUMAN DEVELOPMENTAL GENETICS **(22 Periods)**

1. Principles of Developmental Biology - Genetic approaches, Genetic marking, Genetic malformations. **(2 Periods)**

2. Developmental patterns – Developmental dynamics of cell specification (Autonomous, Syncytial & Conditional), Morphogenetic fields. **(2 Periods)**

3. The Genetic core of development - The Embryological origins of Gene Theory, Early attempts at Developmental Genetics, Genomic equivalence, determining the function of genes during development, Gene targeting (Knockout) experiments, determining function of a message : Antisense RNA. **(2 Periods)**

4. Genetics of cell-cell communication in development - JAK-STAT pathway, Hedgehog pathway, 'Canonical' WNT pathway, "non-Canonical" WNT pathway, SMAD pathway, cell death pathways, Juxtacrine signaling & Cell patterning. **(2 Periods)**

5. Differential gene expression from the same nuclear repertoire – differential gene transcription, selective nuclear RNA processing, Selective mRNA translation, differential protein modification, DNA methylation & gene activity, chromatin modification induced by DNA methylation, dosage compensation, X-inactivation in Human female, miRNA in transcriptional gene regulation. **(2 Periods)**

6. Developmental mechanisms of Evolutionary change – 'Unity of Type & 'Conditions of Existence', preconditions for Macroevolution through developmental change – Modularity & Molecular parsimony, mechanisms of macroevolutionary change, Homologous pathways of development, Developmental constraints (Physical, Morphogenetic & Phyletic). **(2 Periods)**

7. Genetics of Metamorphosis, Regeneration & Aging – Compensatory regeneration in the Mammalian Liver, Causes of Aging, Genetically regulated pathway of Aging. **(2 Periods)**

8. Developmental Biology in Human - Structure, chemistry, dynamics and regulation of sperm locomotion, capacitation and egg -surface targeting. Molecular biology, Cytology and Biochemistry of oogenesis: Synthesis and storage of maternal transcripts, proteins and cell organelles. Ovulation and hormonal control in mammals. Molecular and cellular biology of fertilization: acrosome reaction and signal transduction, monospermy and species -specificity. Egg activation, early cleavages and blastocyst formation in mammals and biochemical and cellular changes during the passage down the oviduct to the uterus. Gastrulation in mammals -formation of primitive streak, morphogenetic movements and neural induction. **(5 Periods)**

9. Medical implications of Developmental Biology – Genetic errors of Human development, inborn errors of nuclear RNA processing & translation, identifying the genes for Human developmental anomalies, Teratogenesis – environmental assaults on Human development. **(3 Periods)**

Recommended Texts & References:

1. Developmental Biology , NJ Berrill (Tata McGraw-Hill)
2. Developmental Biology , Scott F Gilbert

MSGEN (ABT)-304 : Animal Biotechnology - I

Module I : ANIMAL PHYSIOLOGY **(20 Periods)**

1. Animals and Environments - The Importance of Physiology, Animals & Environments**.**

2. Molecules and Cells in Animal Physiology - Cell Membranes and Intracellular Membranes, Epithelia, Elements of Metabolism, Enzyme Fundamentals, Regulation of Cell Function by, Enzymes, Cell Signaling: Signal Reception and Cell-Signal Transduction.

3. Transport of Solutes and Water - Passive Solute Transport by Simple Diffusion, Passive Solute Transport by Facilitated Diffusion, Active Transport, Modulation of Channels and Transporters, Osmotic Pressure and Other Colligative Properties of Aqueous Solutions, Osmosis.

4. Food, Energy, and Temperature - Nutrition, Feeding, Digestion, Absorption, Responses to Eating, Energy Metabolism, Why Animals Need Energy : The Second Law of Thermodynamics, Fundamentals of Animal Energetics, Metabolic Rate: Meaning and Measurement, Factors That Affect Metabolic Rates, Basal Metabolic Rate and Standard Metabolic Rate, The Relation between Metabolic Rate and Body Size, The Energetics of Aerobic Activity, Thermal Relations (Temperature and Heat, Heat Transfer between Animals and Their Environments), Poikilothermy (Ectothermy). Homeothermy in Mammals and Birds, Warm-Bodied Fish, Endothermy and Homeothermy in Insects, Costs & benefits of Ectothermy & Endothermy, Circadian Rhythms, Hibernation & Aestivation, Thermoregulatory Control, Fever and Behavioral Fever.

5. Aerobic and Anaerobic Forms of Metabolism - Mechanisms of ATP Production and Their Implications, Comparative Properties of Mechanisms of ATP Production, Two Themes in Exercise Physiology: Fatigue and Muscle Fiber Types, The Interplay of Aerobic and Anaerobic Catabolism during Exercise, Responses to Impaired O2 Influx from the Environment, The Biochemistry of Coupling and Uncoupling of Oxidative Phosphorylation: The Chemiosmotic Theory, Genetic Engineering as a Tool to Test Physiological Hypotheses, Human Peak O2 Consumption and Physical Performance at High Altitudes.

6. Integrating Systems -
Neural and Endocrine Control, Nervous Systems, and Biological Clocks - The Physiology of Control: Neurons and Endocrine Cells Compared, The Organization and Evolution of Nervous Systems, The Vertebrate Nervous System: A Guide to the General Organizational Features of Nervous Systems, Biological Clocks.

Neurons - The Cellular Organization of Nervous Systems, The Ionic Basis of Membrane Potentials, The Action Potential, Propagation of Action Potentials.

Synapses - Synaptic Transmission is usually Chemical but can be Electrical, Synaptic Potentials, Kinds of Neurotransmitters, Synaptic Receptors, Synaptic Plasticity: Synapses Change Properties with Time and Activity, Neuropeptides and Pain.

7. Sensory Processes - Organization of Sensory Systems, Receptor Functions and Their Control, Photoreception, Visual Sensory Processing, Arthropod Visual Systems, Extra-ocular photoreception, Photo-behavioral response, Olfactory (smell) mechanism, Gustatory (taste) mechanism, Mechano-reception, mechanoreceptors in Fish & Insects, Chemoreception, Thermoreception in Snake, Electro-reception, Echolocation.

8. Endocrine and Neuroendocrine Physiology - Introduction to Endocrine Principles, Synthesis, Storage, and Release of Hormones, Types of Endocrine Glands and Cells, Control of Endocrine Systems: The Vertebrate Pituitary Gland, The Mammalian Stress Response, Endocrine Control of Nutrient Metabolism in Mammals, Endocrine Control of Salt and Water Balance in Vertebrates, Hormones and Other Chemical Signals, Pheromones & their functions, Insect Metamorphosis.

9. Reproduction - Sexual and Asexual Reproduction, Mammalian Reproduction, Hormonal Control of Female Reproduction, Hormonal Control of Male Reproduction, Fertilization, Pregnancy and Birth in Eutherian Mammals, Lactation, Maximizing Reproductive Success, "Male Menopause" in a Marsupial Mouse.

10. Muscle and Movement - Vertebrate Skeletal Muscle, Excitation-Contraction Coupling, Whole Skeletal Muscles, Muscle Energetics, Neural Control of Skeletal Muscle, Vertebrate Smooth Muscle, Vertebrate Cardiac Muscle, Electrifying Fishes: Electric Fish Exploit Modified Skeletal Muscles to Generate Electric Shocks, Insect Flight, Control of Movement: The Motor Bases of Animal Behavior, Behavioral Background: Reflexes and Fixed

Action Patterns, Neural Circuits Mediating Reflexes and Fixed Acts, Action Patterns: Neural Generation of Rhythmic Behavior, Control and Coordination of Vertebrate Movement.

11. Transport of Oxygen and Carbon Dioxide - The Properties of Gases in Gas Phases and Aqueous Solutions, Diffusion of Gases, Convective Transport of Gases, The Oxygen Cascade, The Oxygen Debt, Expressing the Amounts and Partial Pressures of Gases in Other Units, The Contrasting Physical Properties of Air and Water, Respiratory Environments, External Respiration: The Physiology of Breathing, Fundamental Concepts of External Respiration,

Principles of Gas Exchange by Active Ventilation, Introduction to Vertebrate Breathing, Breathing by Fish, Amphibians, Reptiles, Mammals, Birds, Aquatic Invertebrates and Allied Groups, Insects and other Tracheate Arthropods, The Book Lungs of Arachnids, The Chemical Properties and Distributions of the Respiratory Pigments, The O2-Binding Characteristics of Respiratory Pigments, The Functions of Respiratory Pigments in Animals.

12. Circulation – Types of Hearts in Animals, Principles of Pressure, Resistance, and Flow in Vascular Systems, Circulation in Mammals and Birds, Circulation in Fish, Amphibians and Reptiles, Concluding Comments on Vertebrates, Invertebrates with Closed Circulatory Systems, Invertebrates with Open Circulatory Systems.

13. Water, Salts, and Excretion - Water and Salt Physiology: Introduction and Mechanisms, The Importance of Animal Body Fluids, The Relations among Body Fluids, The Types of Regulation and Conformity, Organs of Blood Regulation, Osmoregulation in freshwater, marine, and terrestrial animals, major structures involved in osmoregulation and excretion, Responses to Drying of the Habitat in Aquatic Animals, Animals on Land: Fundamental Physiological Principles, Control of Water and Salt Balance in Terrestrial Animals.

14. Kidneys and Excretion - Basic Mechanisms of Kidney Function, Urine Formation in Amphibians, Mammals, Other Vertebrates, Decapod Crustaceans, Molluscs and Insects, Nitrogen Disposition and Excretion, Mammals of the Deserts and Dry Savannahs, Water Balance in Deserts and Dry Savannas, Adaptations of Large Mammals to Arid Environments.

Module II : ANIMAL DEVELOPMENTAL GENETICS **(22 Periods)**

1. Principles of Developmental Biology - Genetic approaches, Genetic marking, Genetic malformations. **(2 Periods)**

2. Developmental patterns – Developmental dynamics of cell specification (Autonomous, Syncytial & Conditional), Morphogenetic fields. **(2 Periods)**

3. The Genetic core of development - The Embryological origins of Gene Theory, Early attempts at Developmental Genetics, Genomic equivalence, determining the function of genes during development, Gene targeting (Knockout) experiments, determining function of a message : Antisense RNA. **(2 Periods)**

4. Genetics of cell-cell communication in development - JAK-STAT pathway, Hedgehog pathway, 'Canonical' WNT pathway, "non-Canonical" WNT pathway, SMAD pathway, cell death pathways, Juxtacrine signaling & Cell patterning. **(2 Periods)**

5. Differential gene expression from the same nuclear repertoire – differential gene transcription, selective nuclear RNA processing, Selective mRNA translation, differential protein modification, DNA methylation & gene activity, chromatin modification induced by DNA methylation, dosage compensation, X-inactivation in Human female, miRNA in transcriptional gene regulation. **(2 Periods)**

6. Developmental mechanisms of Evolutionary change – 'Unity of Type & 'Conditions of Existence', preconditions for Macroevolution through developmental change – Modularity & Molecular parsimony, mechanisms of macroevolutionary change, Homologous pathways of development, Developmental constraints (Physical, Morphogenetic & Phyletic). **(2 Periods)**

7. Genetics of Metamorphosis, Regeneration & Aging – Metamorphosis in Insects, Metamorphosis in Amphibia, Morphallactic Regeneration in Hydra, Epimorphic regeneration of Salamander limbs, Compensatory regeneration in the Mammalian Liver, Causes of Aging, Genetically regulated pathway of Aging.
(2 Periods)

8. Environmental regulation of Animal development – Phenotypic plasticity, Environment – as part of normal development, Polyphenisms & Plasticity, environmentally adaptive nervous system, Endocrine disruptors.
(2 Periods)

9. Genetic analysis of developmental pathways in model organisms – Drosophila, C. elegans, Xenopus, Zebrafish, Chick & Mouse. **(6 Periods)**

Recommended Texts & References:

1. Developmental Biology , NJ Berrill (Tata McGraw-Hill)
2. Developmental Biology , Scott F Gilbert

MSGEN (PBT)-304 : Plant Biotechnology - I

Module I : PLANT PHYSIOLOGY **(20 Periods)**

1. Plant Anatomy (Phytotomy) - Flower anatomy (Calyx, Corolla, Androecium, Gynoecium), Leaf anatomy, Stem anatomy, Fruit/Seed anatomy (Ovule, Seed structure, Pericarp, Accessory fruit), Wood anatomy (Bark, Cork, Phloem, Vascular cambium, Heartwood and sapwood, branch collar), Root anatomy.

2. Plant Morphology (Phytomorphology) - A comparative science (Homology & Convergence), Vegetative and reproductive characters (use in identification), Alternation of generations, Plant development (Plant growth, Juvenility, Environmental effects).

3. Transport and Translocation of Water and Solutes - Water and Plant Cells, Wilting and Plasmolysis, Water Balance of Plants, Water Movement in Xylem and Phloem, Leaf Transpiration and Water Vapor Gradients, Solute Transport.

4. Photosynthesis – Overview, In Plants, Algae and Bacteria, The Light Reactions**,** Redox Reactions, Oxygen Evolution, Photosystem I, Carbon Fixation, Calvin-Benson Cycle, Rubisco: A Model Enzyme for Studying Structure and Function, Factors affecting photosynthesis, Carbon Dioxide: Some Important Physicochemical Properties, C_4, C_3 and CAM, Three Variations of C_4 Metabolism, Circadian rhythm in Plants.

5. Respiration - Aerobic respiration (Glycolysis**,** Oxidative decarboxylation of pyruvate, Citric Acid cycle/Krebs cycle, Oxidative phosphorylation, Theoretical yields of ATP (Pyruvate carrier, Phosphate carrier, Adenine nucleotide carrier), Anaerobic respiration, Oxidative Phosphorylation of Plant Mitochondria.

6. Plant Nutrition – Processes, essential nutrients of plants, Assimilation of Mineral Nutrients.

7. Growth and Development - Embryonic Dormancy, Shoot Branching, Phytochrome and Light Control of Plant Development, Stomatal Movements and Morphogenesis.

8. Phytohormones – Characteristics, Classes of plant hormones, **Auxin** (The Growth Hormone) - The Structural Requirements for Auxin Activity, **Gibberellins** (Regulators of Plant Height), Auxin-GA Interaction, **Cytokinins** (Regulators of Cell Division) - Cytokinin Can Promote Light-Mediated Development, **Ethylene** (The Gaseous Hormone), **Abscisic Acid** (A Seed Maturation and Antistress Signal).

9. Dormancy & Germination - Germination rate, Seed germination, Dicot germination (Epigeous & Hypogeous), Monocot germination, Precocious germination, Requirements for seed germination, Hormonal control in germination, Pollen germination, Spore germination in Resting spores, Zoospores, Ferns and mosses, early seedling development, Photomorphogenesis and skotomorphogenesis, Seedling growth and maturation, Sporeling development, Seeds that can be sprouted, Sprouting.

10. The Control of Flowering – Photoperiodism, Genes that Control Flowering Time, The Different Effects of Two Different Gibberellins on Flowering (Spike Length) and Elongation (Stem Length), The Influence of Cytokinins and Polyamines on Flowering, The Contrasting Effects of Phytochromes A and B on Flowering, A Gene That Regulates the Floral Stimulus in Maize.

11. Plant pathology & biological control of Plant diseases - Plant Disease Epidemiology and Management, Current concepts and approaches to managing plant pathogens and diseases in crops and natural plant communities by measures that have minimal impact on the environment, naturally-occurring biological control (suppressive soils and induced host resistance), use of microbial agents and their modes of action, transgenic disease resistance, use of organic soil to promote microbial diversity and suppress pathogens, and effects of sanitation, crop sequences, tillage, flooding, soil solarization and other cultural practices on microbial communities, including pathogens and on disease epidemics.

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Module II : PLANT DEVELOPMENTAL GENETICS **(22 Periods)**

1. Principles of Developmental Biology - Genetic approaches, Genetic marking, Genetic malformations.
(2 Periods)

2. Developmental patterns – Developmental dynamics of cell specification (Autonomous, Syncytial & Conditional), Morphogenetic fields. **(2 Periods)**

3. The Genetic core of development - The Embryological origins of Gene Theory, Early attempts at Developmental Genetics, Genomic equivalence, determining the function of genes during development, Gene targeting (Knockout) experiments, determining function of a message : Antisense RNA.
(2 Periods)

4. Genetics of cell-cell communication in development - JAK-STAT pathway, Hedgehog pathway, 'Canonical' WNT pathway, "non-Canonical" WNT pathway, SMAD pathway, cell death pathways, Juxtacrine signaling & Cell patterning.
(2 Periods)

5. Differential gene expression from the same nuclear repertoire – differential gene transcription, selective nuclear RNA processing, Selective mRNA translation, differential protein modification, DNA methylation & gene activity, chromatin modification induced by DNA methylation, miRNA in transcriptional gene regulation.
(2 Periods)

6. Developmental mechanisms of Evolutionary change – 'Unity of Type & 'Conditions of Existence', preconditions for Macroevolution through developmental change – Modularity & Molecular parsimony, mechanisms of macroevolutionary change, Homologous pathways of development, Developmental constraints (Physical, Morphogenetic & Phyletic). **(2 Periods)**

7. Environmental regulation of Plant development –Environment – as part of normal development,
(4 Periods)

8. Genetic analysis of developmental pathways in model plants – Yeast, Arabidopsis
(6 Periods)

Recommended Texts & References:

1. Developmental Biology , NJ Berrill (Tata McGraw-Hill)
2. Developmental Biology , Scott F Gilbert

MSGEN (EBT)-304 : Environmental Biotechnology - I

Module I : ENVIRONMENTAL BIOLOGY **(20 Periods)**

Ecology & Environment

The Ecosystem Concept, Biomes, Autotrophs, Heterotrophs, trophic levels, Bio-geo-chemical cycles, Competition, predation, succession, symbiosis, Coevolution, Energy flow in ecosystems, Biogeochemical cycles, Population

Dynamics, genetic responses to niche & competition (isolating mechanisms, character displacement, resource partitioning, niche shift & niche exclusion), Microbial ecology.

Community classification, Community structure & measurement of associations between species, Diversity indices, hierarchical classification.

Survey methods, Relative & absolute methods for estimating plant population sizes & community structure, survey design, distribution patterns & quadrat sizes, Design of the survey program for single species & communities.

Ecological sampling theory, sample sizes, locations of sampling effort, methods of sampling, Natural resources and their conservation.

Human Impacts on Ecosystem, Deforestation Desertification

Restoration ecology - Rationale for Restoration, Approaches, Focuses of Conservation Biology and Restoration Ecology, Ethical Considerations.

Environmental Pollution

Major primary pollutants produced by human activities,

Air pollution – Pollutants, Sources of air pollution, Indoor air quality (IAQ), Acid rain, Air Quality Index, Atmospheric dispersion modeling, Chlorofluorocarbon, Global dimming, Global warming, Haze, Indoor air quality, Ozone depletion, Particulate, Smog, Green House Effect, Ocean Acidification, Health effects.

Water pollution - Eutrophication, Hypoxia, Marine pollution, Ocean acidification, Oil spill, Ship pollution, Soil erosion, Surface runoff, Thermal pollution, Wastewater, Waterborne diseases, Water quality, Water stagnation.

Soil Pollution – by Herbicide & Pesticide, Soil Guideline Values – SGVs.

Radioactive contamination - Actinides in the environment, Environmental radioactivity, Fission product, Nuclear fallout, Plutonium in the environment, Radiation poisoning, radium in the environment, Uranium in the environment.

Other types of pollution - Invasive species, Light pollution, Noise pollution, Radio spectrum pollution, Visual pollution.

Module II : ENVIRONMENTAL PHYSIOLOGY **(22 Periods)**

Ecophysiology - Ecophysiology of plants & animals, Ecological Health.

Environmental Physiology in Animals - Nature and Levels of Adaptation, Fundamental Mechanisms of Adaptation,

Comparative Physiology - Water, Ions, And Osmotic Physiology, Animal Water Balance, Osmoregulation and Excretion, Metabolism and Energy Supply, Respiration and Circulation, Temperature and its effects, Excitable Tissues Nervous Systems and Muscles, Hormones and Chemical Control Systems.

Coping with the Environment – Introduction, Marine Life, Shorelines and Estuaries, Fresh Water, Special Aquatic Habitats, Terrestrial Life, Extreme Terrestrial Habitats, Parasitic Habitats.

Environmental Chemistry – Concepts, Environmental indicators, methods & applications

Major organizations & Inter-government treaties – DEFRA, EPA, Global Atmosphere Watch, Greenpeace, National Ambient Air Quality Standards, Montreal Protocol, Nitrogen Oxide Protocol, Kyoto Protocol, CLRTAP.

Recommended Text:

1. Ecology, The experimental analysis of distribution and abundance, Krebs C.J.
2. Fundamentals of Ecology, Odum E.P.
3. Environmental Science, E. Enger & B. Smith
4. Environment, P.H.Raven, L.R. Berg, and G.B. Johnson
5. General Ecology, H D. Kumar, Vikas Pub.

MSGEN (MBT)-305 : Medical Biotechnology - II

Module I : HUMAN MOLECULAR GENETICS **(22 Periods)**

Inherited Human diseases - single gene diseases, complex traits.

Identification and isolation of disease genes – positional cloning, functional cloning, DNA and Cdna microarrays, Yeast two-hybrid system.

Pre-natal diagnosis - chorionic villus sampling, amniocentesis, Pre-implantation genetic diagnosis, Genetic Counseling.

Methods for genetic study in man – pedigree analysis, chromosomal analysis, biochemical analysis, Statistical methods for genetic analysis of complex traits.

Somatic cell Genetics - somatic cell hybrids, radiation hybrids, monochromosome, hybrid panels, gene mapping, molecular genetic analysis.

Congenital abnormalities - clinical aspects of autosomal and sex chromosomal disorders; inborn errors of metabolism, haemoglobinopathies.

Human Genome and its relationship to other genome - Genome projects and modeled organisms / organization of human genome / Human gene expression / Instability of human genome (mutation and DNA repair)

Sequencing Genome – Use of genomic data, Genetic screening, applications.

Mapping and identifying disease genes and mutations - Gene mapping of Mendelian characters / Identifying human disease genes / mapping and identifying genes conferring susceptibility to complex diseases / Molecular Pathology / Cancer genetics

Genetic manipulation of cells and animals - Overview / principle of gene transfer / methods of gene transfer to animal cells culture / selectable markers for anima cells / Isolation and manipulation of mammalian embryonic stem cells / Using gene transfer to study gene expression and function/ creating disease models using gene transfer and gene targeting technology / potential of animal for modeling human disease

New Approaches to treating disease - Treatment of genetic disease is not the same as genetic treatment / Treatment of genetic disease / principle of gene therapy / methods of inserting and expressing a gene in a target cell or tissue / Methods for repairing or inactivating a pathogenic gene in a cell

Gene therapy - concept, vectors, gene targeting and tissue-specific expression, Ethics and human genetics, Introduction to pharmacogenomics and toxicogenomics.

Recommended Text:

Module II – IMMUNOTECHNOLOGY **(20 Periods)**

Immunology – Overview: concept of self and nonself, antigens, antibodies; immune response,
evolution of immune response, immunological tolerance, hypersensitivity, humoral and cell-mediated immunity, active and passive immunization, Allergy, immunoprophylaxis.

Antibody-Immunoglobulins – classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes.

Immunobiology – development of the immune system, development of the lymphoid tissue, cellular basis of immunity, T cell receptor.

Antigen-antibody reactions – complement fixation, agglutination, precipitation, immuno-diffusion, immuno-electrophoresis, Immuno-fluorescence, enzyme-linked immunosorbant assay (ELISA), radioimmunoassay (RIA).

Immunogenetics – blood groups and transplantation antigens, HLA and disease association, Immune deficiencies and disorders, immunological diseases including AIDS, antigen processing and MHC, Theories of antibody synthesis and generation of antibody diversity-molecular basis.

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity, alternate pathways of transcript splicing, variable joining sites & somatic mutation, role of antibody (alone, in complement activation & with effector cells), monoclonal antibodies.

Immunity to infections – by viruses, bacteria, fungi and parasites and immunity to tumors, autoimmune diseases – aetiology, pathogenesis and treatment.

Vaccines - adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, tumor vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs.

Drugs - Antimetabolites, corticosteroids, anti -inflammatory agents

Cytokinins - Cytokinins regulating immune inflammation: interleukin -4, interleukin-10, interleukin-12, The interferons: Basic biology and therapeutic potential Treatment of inflammatory diseases

Macromolecules - Intravenous immunoglobulin therapy, Treatment of angioedema resulting from Cl inhibitor deficiency

Antibodies and antibody based therapy - Characteristics of animal cells and their implication on process design, Nutritional requirements and serum free culture of mammalian cells, Kineti cs of growth and product formation. Reactor systems for large -scale production using animal cells. Production of Polyclonal antibodies with different types of antigens : antigen preparation and modification, adjuvant, dose and route of antigen administratio n, collection of sera, purification of antibodies, Inhibitors of tumor necrosis factor, targeting the IL2 receptor with antibodies or chimeric toxins, monoclonal antibodies to CD3

Hybridoma technology – production and applications of monoclonal antibodies for diagnosis and therapy.

Immunotherapy for allergic diseases - Specific and nonspecific immunotherapy for Asthma and allergic diseases, insect stings etc.

Vaccine & peptide therapy in Transplantation - Renal, pancreas, cardiac, lung, liver transplantation, xenotransplantation.

Cellular & Drug therapy in HIV - Tumor Immunology, AIDS and other Immunodeficiencies.

Recommended Texts :
Therapeutic Immunology, authors.. K Frank Austen, Steven J Burakoff, Fred Rosen, Terry B Strom, Publisher : Blackwell Science

MSGEN (ABT)-305 : Animal Biotechnology - II

Module I : GENETIC ENGINEERING IN ANIMALS **(22 Periods)**

Animal biotechnology - an overview, Applications of biotechnology to animal production (Reproduction, selection and breeding; Animal health; Feeding and nutrition; Growth and production).

Principles of animal cell and tissue culture - Techniques of animal cell and tissue culture, Enzymes in Genetic Engineering (Nucleic Acid Enzymology).

Gene Transfer methods in Animals - Gene cloning vectors, Techniques for genetic engineering, Gene cloning, Gene transfer and expression of induced genes, Microinjection, Embryonic-stem cells Transfer, Retro-virus and Gene transfer, Xenografting.

Transgenic Animals – Development of Transgenic Science, Transgene DNA Preparation, Microinjection Technique, Embryo Transfer, Transgenic Animal Models - Mice, Cows, Pig, Sheep, Goats, Birds, Fish, Insects, Biotech products from Transgenic animals.

Animal Propagation and Development of transgenic livestock - Artificial Insemination, Animal clones, Animal Pharming: The Industrialization of Transgenic Animals**.**

Conservation Biology - Artificial animal breeding, Embryo transfer.

Animal Health Biotechnology – Protection of Experimental Animals, Animal Biosafety (Use of Biological Agents in Animals, Use of Mammalian Cultures, Use of Transplantable Cells and Tumors in Animals, Use of Biological Derived Toxins and Chemicals in Animals), Animal Bites and Scratches, Animal-associated Allergies, Procedures for Biological decontaminations, International Animal Health Organizations.

Regulation and Biosafety of Animal testing – History, Animal testing on invertebrates, Rodents, non-Human Primates, Regulations in Europe, France, United Kingdom, Japan, United States, Species of Animals used, Types of experiment on Animals (Pure research, Applied research, Xenotransplantation, Drug testing, Cosmetics testing), Controversy, Alternatives to animal testing, Advocates of animal testing, Governmental and medical group statements, Opponents of animal testing.

Regulation and Biosafety of transgenic animals - Value of Transgenic Animals, Biosafety measures in Transgenic Animal Research, Compliance with NIH Guidelines, Policies & Protocols, Disposal of Transgenic Animals, Transfer of Recombinant DNA and Transgenic Materials.

Patenting Genetically Engineered Animals - Trends in Biotechnology Patenting, Biotech Patent Processing, Pharmaceutical Biotech Patents, Genetic Engineering Patents, PTO Analysis, Patent protection of living organisms, Gene technology laws in other countries.

Recommended Texts :

Animal Biotechnology : M.M. Ranga. Reprint. Jodhpur, Student Edition, 2007,

Module II – IMMUNOTECHNOLOGY (20 Periods)

Immunology – Overview: concept of self and nonself, antigens, antibodies; immune response,
evolution of immune response, immunological tolerance, hypersensitivity, humoral and cell-mediated immunity, active and passive immunization, Allergy, immunoprophylaxis.

Antibody-Immunoglobulins – classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes.

Immunobiology – development of the immune system, development of the lymphoid tissue, cellular basis of immunity, T cell receptor.

Antigen-antibody reactions – complement fixation, agglutination, precipitation, immuno-diffusion, immuno-electrophoresis, Immuno-fluorescence, enzyme-linked immunosorbant assay (ELISA), radioimmunoassay (RIA).

Immunogenetics – blood groups and transplantation antigens, HLA and disease association, Immune deficiencies and disorders, immunological diseases including AIDS, antigen processing and MHC, Theories of antibody synthesis and generation of antibody diversity-molecular basis.

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity, alternate pathways of transcript splicing, variable joining sites & somatic mutation, role of antibody (alone, in complement activation & with effector cells), monoclonal antibodies.

Immunity to infections – by viruses, bacteria, fungi and parasites and immunity to tumors, autoimmune diseases – aetiology, pathogenesis and treatment.

Vaccines - adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, tumor vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs.

Drugs - Antimetabolites, corticosteroids, anti -inflammatory agents

Cytokinins - Cytokinins regulating immune inflammation: interleukin -4, interleukin-10, interleukin-12, The interferons: Basic biology and therapeutic potential Treatment of inflammatory diseases

Macromolecules - Intravenous immunoglobulin therapy, Treatment of angioedema resulting from Cl inhibitor deficiency

Antibodies and antibody based therapy - Characteristics of animal cells and their implication on process design, Nutritional requirements and serum free culture of mammalian cells, Kineti cs of growth and product formation. Reactor systems for large -scale production using animal cells. Production of Polyclonal antibodies with different types of antigens : antigen preparation and modification, adjuvant, dose and route of antigen administratio n, collection of sera, purification of antibodies, Inhibitors of tumor necrosis factor, targeting the IL2 receptor with antibodies or chimeric toxins, monoclonal antibodies to CD3

Hybridoma technology – production and applications of monoclonal antibodies for diagnosis
and therapy.

Immunotherapy for allergic diseases - Specific and nonspecific immunotherapy for Asthma and allergic diseases, insect stings etc.

Vaccine & peptide therapy in Transplantation - Renal, pancreas, cardiac, lung, liver transplantation, xenotransplantation.

Cellular & Drug therapy in HIV - Tumor Immunology, AIDS and other Immunodeficiencies.

Recommended Texts :
Therapeutic Immunology, authors.. K Frank Austen, Steven J Burakoff, Fred Rosen,
Terry B Strom, Publisher : Blackwell Science

MSGEN (PBT)-305 : Plant Biotechnology - II

Module I : PLANT TISSUE CULTURE & APPLICATION **(20 Periods)**

Introduction to Plant cells & Organelles - Plasma membrane, Cell Wall, Endoplasmic reticulum, GolgiApparatus, Vacuoles, Nucleus, Peroxisomes, Plastids, Mitochondria and Chloroplasts

Plant Tissue Culture - Micropropagation, From callus to plant, Somatic embryogenesis, The culture environment, Plant Cell culture media, Plant growth regulators and their biosynthesis and function, Culture types - Callus, Cellsuspension culture, protoplasts, Root culture, Shoot tip and meristem culture, embryo culture, microspore culture, Somaclonal variation, Polyploidy, Genetically engineered plants, Plant made Pharmaceuticals, Plasticity and Totipotency.

Plant secondary metabolites - Introduction to primary and secondary metabolism, important pathway leading to the biosynthesis of secondary metabolite in plants, Metabolic products produced by in vitro culturing of plant cells, selection of plant cells/tissues for the production of a specific product, Culture system in secondary plant product biosynthesis -batch continuous cultures and immobilized plant cells, Biotransformation of precursors by cell culturing. Metabolic engineering for production of secondary metabolites

Module II : GENETIC ENGINEERING IN PLANTS **(22 Periods)**

Plant Genome : Organization and expression of plant genes - Gene structure and expression, translation, regulation of gene expression, Implication of plant transformations, Plant promoters, terminators, reporters, selectable markers

Plant Transformation Techniques – Plant transformation techniques, Cloning of Plant Cells and Manipulation of Plant Genes, About the Cloning Vector that Works with Plant Cells, Agrobacterium mediated gene transfer- Biology and molecular basis of Agrobacterium mediated plant transformation and its application, Overcoming the Limited Range of A. Tumefaciens Infection, Direct gene transfer methods, Development of plant vectors for transformation and features, clean gene technology, Plant Breeding vs Genetic Engineering.

Mutagenesis and Cloning of Genes - Mendelian Genetics, Concept of forward and reverse genetics, Principles of conventional breeding, Generation of Mutants in plants-TDNA and transposon based gene knockouts, chemical mutagenesis, Linkage analysis, Calculation of Map distance, DNA polymorphic markers, Map based Cloning

Application of Plant Genetic Engineering - Crop improvement, Herbicide Resistance, Insect resistance, Virus Resistance, Tolerance of environmental extremes in crops - drought, cold, salinity, flooding, Aluminium, Plant as Bioreactors, Genetically engineered food, manufacture of pharmaceutical products in plants using modified plant viruses, Biofuels and Bioplastics from genetically engineered oil seed rape and other crops as substitutes for fossil fuels, which should not worsen the Greenhouse effect.

Gene silencing in plants - Post transcriptional and transcriptional gene silencing, mutants of gene silencing, RNA virus in p lants, virus induced gene silencing and its application

Signal Perception and Transduction - Overview, Plant receptors, G protein and phospholipids signaling, cyclic nucleotides, Role of Calcium in signaling, Protein kinases as primary elements in signaling, Particular pathways of signal transduction associated with plant growth regulators

Plant disease resistance - Types of pathogen and their mode of action, Plant defense system, Constitutive and inducible defense, Genetic basis of plant pathogen interaction, R genes and R gene mediated resistance, Biochemistry and Molecular biology of defense reactions, Systemic acquired resistance, Control of plant pathogen by genetic engineering, Role of Salicylic acid Jasmonic acid and ethylene in plant defense

Plant Abiotic stress response - Osmotic adjustment and its role in drought and salinity tolerance, ABA in stress tolerance, ABA dependent and independent genes, cis and trans acting factors freezing and heat stress, Strategies for genetic engineering of stress tolerance

Improvement of crop yield and quality - Role of Ethylene in fruit ripening, Mutants in fruit ripening, Genetic manipulation of fruit ripening, Molecular Farming & Plantibodies, Reversible male sterility in plants, Antisense RNA, Agricultural applications in developing countries.

Genetic Engineering and public Concerns – Ethical & Environmental concerns on Genetic Engineering of plants.

Plant Genetic Engineering Future - Genetically Engineered Foods, Safety of Genetically Engineered Foods, Labeling, Future Foods and Regulatory Challenges, 'Pharm' Factories of the Future.

Recommended Texts :

Buchanan, Taiz& Zeiger
Buchanan,Slater
Buchanan, Alberts

MSGEN (EBT)-305 : Environmental Biotechnology - II

Module I : BIOLOGICAL CONTROL OF ENVIRONMENT **(20 Periods)**

Control of Pollution - Pollution monitoring & environmental management, Biological monitoring of water quality and indicator species, algal indicators, blooms and toxins, macro-invertebrate indicator species, water-borne parasites and disease organisms.

Pollution and pollution testing - toxicity testing, bioaccumulation of pollutants, solid waste management and disposal, regulating hazardous materials, Environmental risk assessment.

Air Pollution - Air pollution control, Air pollution dispersion modeling, Reduction efforts, Control devices, Particulate control, Scrubbers, NOx control, VOC abatement, SO_2 control, Mercury control, Dioxin and furan control, other associated equipment.

Environmental technology (Green Technology) - Alternative energy, Biofuel, Composting, Ecoforestry, Energy conservation, Energy development, Environmental design, Environmental impact assessment, Environmental preservation, Green building, Hydrogen technologies, Industrial wastewater treatment**,** Natural building, Recycling, Renewable energy, Renewable energy development, Remediation, Solid waste treatment, Sustainable architecture, Sustainable energy, Sustainable development, Waste water treatment, Water purification**,** Waste management, Related technologies (Alternative energy, Energy Saving Modules, Green building, Green syndicalism, Hybrid vehicle, Solar power - Solar cell & Solar heating).

Bioremediation - Overview and applications, Genetic engineering approaches, Advantages, Monitoring bioremediation, Phytoremediation, phytoremediation processes, Advantages and limitations, Mycoremediation, applications for mycoremediation technologies, Mycofiltration, Bioaugmentation, Biosorption, Bioleaching.

Bioreactors for Waste Water Treatment - Biological Processes for Industrial Effluent Treatment, Aerobic Biological Treatment, Anaerobic Biological Treatment, Periodic Biological Reactors, Membrane Bioreactors, Use of Immobilized Enzymes and Microbial Cells.

Environmental Engineering - Development of environmental engineering, Scope of environmental engineering in Environmental impact assessment and mitigation, Water supply and treatment, Wastewater conveyance and treatment, Air quality management, Contaminated land management and site remediation, Risk assessment, Environmental policy and regulation development, Waste management methods (Landfill, Incineration, Resource recovery, Recycling, Composting and anaerobic digestion, Mechanical biological treatment, Pyrolysis & gasification), Solid waste management, Hazardous waste management, Environmental health and safety, Natural resource management, Noise pollution.

Module I : BIOTECHNOLOGY IN ENVIRONMENT **(22 Periods)**

Role of Biotechnology in Environmental Management - in leather processing, Enzymes and microbiological pretreatments of oil industry wastes for biogas production in batch digesters, Lignin biodegradation: a clean technology for paper industry, Microbial technology for composting municipal solid waste, Bioenergy from waste: an alternative to reduce the impact of environmental pollution, Probiotics: a tool for management of aquaculture environment, Treatment and recycling of domestic sewage through aquaculture, Vermicomposting as a biotechnological tool for recycling organic wastes, Production of single cell protein from microorganisms, Ability of polyacrylamide-grafted banana stalk (musa paradisiaca) to remove lead (II) and cadmium (II) ions from aqueous solutions, Biosensors as tools in environmental biotechnology, Biotechnological applications of cyanobacteria in development of clean
technologies for environmental management, Reduce, reuse, recycle and recover: biotechnological approach in management of solid waste of fruit and vegetable processing industries, Food Crop Pest Management,

Role of Biotechnology in Environment Protection - What is Environmental Biotechnology? Current Status of Biotechnology in Environment Protection.

Biotechnology for Hazardous Waste Management - Xenobiotic Compounds, Recalcitrance, Hazardous Wastes, Biodegradation of Xenobiotics, Biological Detoxification, Biotechnology Applications to Hazardous Waste Management, Examples of Biotechnological Applications to Hazardous Waste Management.

Biotechnology for Pesticide Industry - Tannery Industry and Biotechnology. Paper Industry and Biotechnology.

Biotechnology for Waste Treatment of Food and Allied Industries - Biological Treatment Methods, SCP and Biomass from Waste, Distillery Industry.

Biotechniques for Air Pollution Abatement and Odor Control - Deodorization Process, Applications, Solid Waste Management.

Recommended Texts :

1. Biotechnology in Environmental Management/edited by G.R. Pathade and P.K. Goel. Jaipur, ABD, 2004
2. Biotechnology in Environmental Management/edited by T.K. Ghosh, T. Chakrabarti and G. Tripathi. New Delhi, A.P.H. Pub., 2005
3. "Waste water Engineering Treatment and Disposal and Reuse" by Metcalf & Eddy.
4. "Water Pollution Management Hand Book" by Lepathak.
5. "Waste Water Management" by Arceivala.
6. "Environmental Biotechnology" by C. F. Forster and D. A. J. Wase.
7. "New Processes of Waste water treatment and recovery" by G. Mattock (ED) Ellis Horwood. 8. "Biochemical Engineering fundamentals" 2nd ed. by J E Bailey and D F Ollis , McGraw - Hill (1986). Chapters 13 & 14.
9. "Environmental Biotechnology" by Jogdand.

MSc (Genetic Engineering) - THIRD SEMESTER

PRACTICAL PAPERS

MSGEN-306 - Genetic Engineering Tools- II

Analysis of Gene Expression

1. **Screening & Analysis:**
   a) GFP Cloning
   b) Bacterial Gene Expression
   c) Southern Hybridization. **(10 Periods)**

2. **PCR Application:** Single Nucleotide Polymorphism (SNP) **(5 Periods)**

3. **DNA Fingerprinting:**
   a) DNA Fingerprinting (Using RAPD techniques)
   b) Rice variety identification by RAPD analysis
   c) Genotyping Analysis in Human **(15 Periods)**

MSGEN-307 - Bioinformatics

MSGEN-308 - Microbial Biotechnology

Paper Code: MSGEN–308 (Practical) **Full Marks: 100**

Paper Name: Microbial Biotechnology **Practical period: 30**

1. Isolation and selection methods to collect important bacterial strains from the environment, i.e. soil, water and also from compost. **(6 Periods)**

2. Learning of their preservation methods; i.e. (i) Slants, (ii) Vials, (ii) Glycerin based deep freeze, (iv) N2 based glass sealing. **(3 Periods)**

3. Preparation of Ethyl alcohol in laboratory scale **(6 Periods)**
4. a) Citric acid production, its recovery and purification (lab scale) **(3 Periods)**
   b) □-Amylase production, its recovery and purification (lab scale) **(3 Periods)**

5. Preparation of Genetically Engineered bacteria by Transduction, Transformation and Conjugation **(9 periods)**

6. Studies of bacterial growth variations in case of wild type Donor strains and hybrid Genetically Engineered strains **(3 Periods)**

7. Characterizations of proteins in Spectroscopic analysis and enzymatic reactions, namely [S]+[E]→ [SE]→ [E] + [P] for Alkaline Phosphatase isolated from E. coli. **(6 Periods)**

8. Isolation of heavy metal resistant bacteria from soil. **(3 Periods)**

MSGEN (MBT)-309 - Medical Biotechnology - I

Immunology **Practical period : 20**

1. Antigen-Antibody reactions – Agglutination (Blood grouping testing). **(4 Periods)**
2. Antibody titration (Ouchterlony Double Diffusion). **(4 Periods)**
3. Antigen-Antibody reactions – Immuno-electrophoresis, Rocket immuno-electrophoresis. **(8 Periods)**
4. Antigen-Antibody reactions – Coomb's test. **(6 Periods)**
5. Antigen-Antibody reactions – ELISA. **(8 Periods)**

MSGEN (PBT)-309 - Plant Biotechnology – I

MSGEN (ABT)-309 - Animal Biotechnology - I

Immunology **Practical period : 30**

1. Antigen-Antibody reactions – Agglutination (Blood grouping testing). **(4 Periods)**

2. Antibody titration (Ouchterlony Double Diffusion). **(4 Periods)**

3. Antigen-Antibody reactions – Immuno-electrophoresis, Rocket immuno-electrophoresis. **(8 Periods)**

4. Antigen-Antibody reactions – Coomb's test. **(6 Periods)**

5. Antigen-Antibody reactions – ELISA. **(8 Periods)**

MSGEN (EBT)-309 - Environmental Biotechnology – I

MSGEN (MBT)-310- Medical Biotechnology – II

MSGEN (PBT)-310 - Plant Biotechnology – II

MSGEN (ABT)-310 - Animal Biotechnology - II

MSGEN (EBT)-310 - Environmental Biotechnology – II

4th Semester

MSGEN-401 : GENETIC ENGINEERING IN BUSINESS

Genetic Engineering as Commercial venture

1. Size of industry in USA & in India
2. Scope of Business in India
3. Medical & non-Medical markets for products
4. Tax policies
5. Research & Experimentation credit
6. 'Orphan Drug' credit

Global Biotech Products - A Blooming Market for Transgenic Animals and Plants

1. GM Food and GM Crops
2. Animal and Dairy Products
3. Poultry and Fisheries
4. Human Health Products

Production of Plant made pharmaceuticals (PMPs) - Biopharmaceuticals Used in Molecular Medicine

1. Transgenic plants in the biopharmaceutical market
2. Biopharmaceuticals derived from transgenic plants and animals
3. Production of recombinant Proteins, Antibodies, Vaccines & other therapeutic agents in plants
4. ExpressTec: High-level expression of biopharmaceuticals in cereal grains
5. Biopharmaceutical production in cultured plant cells
6. Producing biopharmaceuticals in the desert
7. Making pharmaceuticals in GM animals
8. The first biopharmaceutical from transgenic animals: ATryn®

Market of Industrial Enzymes

1. In Drug development (Penicillin Amidases, Carbohydrase enzymes, Chymosin from Stomach)
2. In Textiles (applications of genetic engineering into textiles, natural polyester such as polyhydroxy butyrate (PHB) production)
3. In new industrial processes
4. In renewable raw materials
5. In genetic engineering and effluent management.

Stem cells – worldwide markets

1. Markets for Transplantation
2. Markets for Cord blood banking
3. Markets for Drug development

Bio-Engineering Products & their markets

1. Markets for Monoclonal Antibodies, DNA probes, Biosensors, Casein, polymers for industrial fermentation, bioplastics, engineered wood,
2. Markets for bioremediation technologies & Superfund programs

MSGEN-402: BIOETHICS & BIOSAFETY

BIOSAFETY

1) Regulatory Aspects of using Genetically Modified Organisms (GMO) ; Introduction / potential risk / risk of invasiveness

a) Direct non-target Effects on beneficial and native organisms
b) Indirect Effects
c) New Viral Diseases.
d) Variability and Unexpected results

2) Regulating Recombinant DNA Technology
a) Approaching the biohazard problem
b) Environmental and Regulatory Aspects of Using Genetically Modified plants
c) Relevance of multiple Environment Testing
d) Environmental and Regulatory aspects of using GMMS

3) International Biosafety protocol

4) International Activities in Biosafety Capacity Building
5) Biosafety Regulations in India
6) Biological Weapons
7) Biosafety and Ethical Issues

BIOETHICS :

Intellectual property rights and Social-legal Aspects of Genetic Engineering and biotechnology

1. **A commercial view of Genetic Engineering and its application in Industry**
2. **Intellectual Property rights and patenting**
3. **Forms of protection**
4. **Patenting Biological material**
5. **International Conventions and Cooperation**
6. **The World Intellectual Property Organization**
7. **General Agreement of Tarrifs and Trade (GATT) and trade related IPRS (TRIPS)**
8. **Implication of Patenting**
9. **Opposition to patents in Biotechnology.**
10. **Special issues (Public opinions against the technologies)**
11. **Legal Issues (legal guide lines of different countries)**
12. **Ethical issues (against the technologies).**

MSGEN(MBT)-403 : MEDICAL BIOTECHNOLOGY-III

1. Human Origins and Evolution

Human origins / Molecular evolution / Molecular clocks / Eugenics

2. Human Chromosomes and Chromosome Behavior :

Human beings have 46 Chromosome in 23 pairs / Chromosome abnormalities are frequent in spontaneous abortions / Chromosome rearrangements can have important genetic effects / polyploidy species have multiple sets of chromosomes / Genome evolution

3. Matters of Sex :

Sexual developments / Traits inherited on sex chromosomes / X Inactivation Equalizes the sexes / Genomic Imprinting

4. **The Genetic basis of Complex Inheritance :**

Multi-factorial trait are determined by multiple genes and the environment / variation in a trait can be separated into genetic and environmental components / artificial selection is a form of " managed evolution" / genetic variation is revealed by correlation between relatives / Pedigree studies of genetic polymorphism are used to map loci for quantitative traits

5. Genetic factors in Common Diseases :

Genetic susceptibility to common disease / Diabetes mellitus / Hypertension / Coronary artery disease / Epilepsies / Schizophrenia / Affective disorders / Alzheimer disease / Haemochromatosis / Venous Thrombosis / Thalassaemia and Sickle cell Anaemia / Mental retardation

6. The Genetics of Behavior :

Genes contribute to most behavior traits / Eating disorders / Sleep / Intelligence / Drug Addiction / Mood Disorders / Schizophrenia

7. Congenital abnormalities and Dysmorphic syndromes :

Incidence / definition and classification of birth defects / Genetic causes of malformation / Environmental Agents (Teratogens) / Malformation of unknown cause / counseling

8. Age of Genomics :

How Genetics became Genomics / Human genome projects begins / technology Drives the sequence Effort / Comparative Genomics / Into future / Treatments of genetic diseases / Gene therapy

MSGEN(PBT)-403 : PLANT BIOTECHNOLOGY-III

1) Plant breeding-from classical to marker-aided selection:-
Molecular markers, their applications, special application in cereal breeding

2) Genetic modifications, transgenic plants and potential of medicinal plants in biotechnology:-
Biotechnological methods for selection of high yield cell lines and production of secondary metabolites in medicinal plants, Biotechnology of Solanaceae alkaloids- a model or an industrial perspective! Glycosylation of recombinant proteins in plants.

3) Genetic variation in wild and agricultural population, Genetic consensus.

4) The importance and targets of plant biotechnology:- Commercial micropropagation, Acclimatization of tissue cultured plants, Photoautotrophic Micropropagation, Achievement of cost effective Tissue culture technology, Use of DNA-microchip in plant tissue culture industry.

5) Cryopreservation and distribution of clonal material

6) Genetically Engineered Food:-"GE Technologies will solve world hunger", Food Patents—Stealing Indigenous Knowledge? Functional Foods—the next wave of GE foods, Terminator Technology, Monsanto—a major player in GE Technology, A Huge Wave of Public Concern

7) Biotechnology of Horticultural Crop:- Improvement Achievements, opportunities and limitations.

8) **Application of plant cell tissue and organ culture- Camptothecin production in cell cultures, biotechnology of flavor compounds and essential oils, Paclitaxol production in plant cell culture**
9) **Increasing productivity;- Lipids, Oilseeds, Starches & Cereals, transgenic Plants with increased nutritional value, Increased levels of Vitamins, Minerals, fatty acids & Essential Amino Acids.**
10) **Plants used as renewable resources;- Potato starch for industry, Soybean oil for industrial use, Drought tolerance maize variety, Genetic engineering in paper industry using Eucalyptus.**
11) **Transgenic plants for phytoremediation of polluted areas and water sources.**
12) **Alternatives to Genetic Engineering:- Biotechnology and the world food supply. Biotechnology and sustainable agriculture**
13) **Current status of Genetically modified crops-a global perspective.**
14) **Transgenic crops;-Priorities and strategies for India**

MSGEN(ABT)-403 : ANIMAL BIOTECHNOLOGY-III

1.Gene transfer methods in animals
Microinjection, ES cell mediated gene transfer, Retroviral gene transfer, Gene transfer by sperm vector method.

2. **Transgenic animals**
-Potential applications of transgenic animals in agriculture, medicine and pharmaceuticals.
-Detail protocols of creation transgenic animals-Mice, cow, goat, sheep, pig ,zebra fish and their applications.

3.**Animal cloning**
- Animal cloning technologies-The Roslyn Technique, The Honolulu technique
-Benefits of animal cloning
-Creation of 'Dolly'

4.**Xenotransplantation in human**
-Choosing the donor species
-Immunological barriers to xenotransplantation
- Biological barriers to xenotransplantation
-Method of attenuating antibody mediated xenograft rejection in human recipients - - -Method of attenuating graft rejection by exp[raising human specific proteins in transgenic organ donor.

5.Current developments in animal biotechnology.
-Impacts of genomics on animal agriculture
-Agricultural applications of transgenic live stocks.
-Livestock cloning
-New vaccine technologies.

6. **Animal reproductive biotechnology**
- Basic anatomy of cattle reproduction ,The estrus cycle, factors affecting cattle reproduction

7. **Assisted reproduction biotechnology**:

-**Estrus synchronization** using prostaglandin, GnRH-PGF based synchronization

_ **Physiological basis of superovulation**, Factors influencing superovulatory responses, Hormononal induction of superovulatory responses in farm animals.

-Artificial insemination (AI) in farm animals (Processing of semen, The technical details of AI ,Timing of insemination for maximum conception, benefits of AI.

--**The embryo transfer technology**(in vitro maturation of sperm and ovum, in vitro fertilization, transfer of embryo to recipient, cryopreservation of embryo, Micromanipulation of embryo-embryo splitting

-Embryo sexing(Non invasive methods: assay of HY antigen, quantification of x-linked enzymes, differential growth of male and female embryos. Invasive methods: Observing Barr bodies, Chromosome analysis,Y-specific DNA probe, y-specific DNA primer and PCR

-Sperm sexing by flow cytometry
Immunological methods to control reproduction:
Antifertility vaccines

-Immunization against gonadotropins and GnRH
-Immunization against gamete surface antigens
Fecundity vaccines

MSGEN(EBT)-403 : ENVIRONMENTAL BIOTECHNOLOGY-III

1. Division of Environment:
(a) AIR, WATER and SOIL
(b) Domestic and Industrial.
(c) Municipal and Market
(d) Medical and Sound Pollution.

2. Global warming.
(a) The cause.
(b) The prevention.
(c) The cures.
(d) The Areas of CO2 reduction.
(e) Technological innovation in fuel and combustion technology.
(f) Biodiesel and NCER

3. Waste water.
(a) The importance of Wastewater.
(b) The measuring devices of BOD and COD and their characteristics corresponding to SS (Suspended solid), TIC (Total Inorganic carbon), TOC (Total organic carbon), DO(Dissolve oxygen), and the methods to measure
(c) MBST and cost estimation at various industrial and municipal effluents. Desalination and recycling of used water in Domestic and Industries.

4. Separation technology applicable in Environ. Biotechnology.
(a) Types of separation technology.
(b) Cost effective separation.
(c) MBST and their cost effective application.
(d) The reason to MBST in cost effective separation and the reason to apply the said separation technology in Biotechnology and Food industries.
(e) Physico-chemical properties of membrane.
(f) Different membrane modules and their applications.

5. Industrially Important Microbes, applicable in waste to Energy Recovery.
(a) Taxonomy.
(b) Pheno-genotypes.
(c) Methods to prepare industrially important microbes.
(d) Presearvation of IIM (Industrially Important Microbes).
(e) The method to use IIM from laboratory scale to industrial scale.