

# **Syllabus for two-year**

## ***M.Sc Course in***

### **Biotechnology**

**(Modified syllabus of M.Sc in General Biotechnology proposed by Biotechnology Consortium India Limited- Dept. of Biotechnology, Govt. of India)**

**DURATION : Four Semesters (Two Years)**  
**Total Marks = 3500**

### **M.Sc BIOTECHNOLOGY**

#### **ABOUT THE COURSE**

The program provides a strong theoretical and practical knowledge of key areas of Biotechnology and its applications. There is a research module to help students survey literature, analyze data and make critical assessments of scientific reports, papers or research proposals, and to plan their own research program.

**The course in total is worth 87 credit points in 4 semesters.**

**TARGET GROUPS** : The main target group is that of **Graduates (BSc)** in the **Biological Sciences** who wish to pursue a career in **Biotechnology** either in industry or academia. The program may also be suitable for those with **BSc in Botany, Zoology, Microbiology, Molecular Biology, Physics, Chemistry, Biochemistry, Food & Nutrition** and **BTech in Biotechnology**, who have a strong interest in Biotechnology.

#### **Theoretical Papers**

**17 Papers (Marks = 1700)**  
**Total Credit = 51**

#### **Practical / Project Papers**

**18 Papers (Marks = 1800)**  
**Total Credit = 36**

**Total Credit in 4 Semesters = 51 + 36 = 87**

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

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

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# M.Sc BIOTECHNOLOGY

## FIRST SEMESTER

**Paper (Theoretical) : 5 Papers = 500 Marks**

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSBT-101	BIOPHYSICS & BIOCHEMISTRY	100	3	42
MSBT-102	CELL AND DEVELOPMENTAL BIOLOGY	100	3	42
MSBT-103	MOLECULAR BIOLOGY	100	3	42
MSBT-104	ANALYTICAL TECHNIQUES	100	3	42
MSBT-105	BIOSTATISTICS AND COMPUTER APPLICATION	100	3	42

**Paper (Practical) : 5 Papers = 500 Marks**

MSBT-106	LAB ON BIOPHYSICAL AND BIOCHEMICAL TECHNIQUES	100	2	40 hrs
MSBT-107	LAB ON CELL BIOLOGY, MICROSCOPY AND INSTRUMENTATION	100	2	40 hrs
MSBT-108	LAB ON MOLECULAR BIOLOGY	100	2	40 hrs
MSBT-109	LAB ON ANALYTICAL TECHNIQUES	100	2	40 hrs
MSBT-110	SEMINAR / JOURNAL CLUB	100	2	40 hrs

**Total Credits = 25**

## SECOND SEMESTER

**Paper (Theoretical) : 5 Papers = 500 Marks**

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSBT-201	IMMUNO-TECHNOLOGY	100	3	42
MSBT-202	MICROBIOLOGY AND INDUSTRIAL APPLICATION	100	3	42
MSBT-203	GENETIC ENGINEERING	100	3	42
MSBT-204	GENETICS	100	3	42
MSBT-205	GENOMICS AND PROTEOMICS	100	3	42

**Paper (Practical) : 5 Papers = 500 Marks**

MSBT-206	LAB ON IMMUNOLOGY	100	2	40 hrs
MSBT-207	LAB ON MICROBIOLOGY	100	2	40 hrs
MSBT-208	LAB ON GENETIC ENGINEERING	100	2	40 hrs
MSBT-209	LAB ON COMPUTER APPLICATION OF GENOMICS AND PROTEOMICS	100	2	40 hrs
MSBT-210	SEMINAR / JOURNAL CLUB	100	2	40 hrs

### THIRD SEMESTER

**Paper (Theoretical) : 5 Papers = 500 Marks**

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSBT-301	BIOPROCESS ENGINEERING AND INDUSTRIAL APPLICATION	100	3	42
MSBT-302	BIOINFORMATICS	100	3	42
MSBT-303	FOOD SCIENCE & BIOTECHNOLOGY	100	3	42
	<u>ELECTIVE - PAPER I</u>	100	3	42
MSBT(PBT)-304	Pharmaceutical Biotechnology-I			
MSBT(MBT)-304	Microbial Biotechnology-I			
MSBT(ABT)-304	Agricultural Biotechnology-I			
MSBT(EBT)-304	Environmental Biotechnology-I			
	<u>ELECTIVE - PAPER II</u>	100	3	42
MSBT(PBT)-305	Pharmaceutical Biotechnology-II			
MSBT(MBT)-305	Microbial Biotechnology-II			
MSBT(ABT)-305	Agricultural Biotechnology-II			
MSBT(EBT)-305	Environmental Biotechnology-II			

**Paper (Practical) : 5 Papers = 500 Marks**

MSBT-306	LAB ON BIOPROCESS ENGINEERING	100	2	40 hrs
MSBT-307	LAB ON BIOINFORMATICS	100	2	40 hrs
MSBT-308	LAB ON FOOD TECHNOLOGY	100	2	40 hrs
	<u>LAB ON ELECTIVE PAPER</u>	100	2	40 hrs
MSBT(PBT)-309	Pharmaceutical Biotechnology Lab			
MSBT(MBT)-309	Microbial Biotechnology Lab			
MSBT(ABT)-309	Agricultural Biotechnology Lab			
MSBT(EBT)-309	Environmental Biotechnology Lab			
MSBT-310	PROJECT PRESENTATION BASED ON ELECTIVE PAPER	100	2	40 hrs

**Total Credits = 25**

## FOURTH SEMESTER

**Paper (Theoretical) : 2 Papers = 200 Marks**

Paper Code	Name of the Paper	Marks	Credit hrs	Classes / Semester
MSBT-401	BIO-ENTREPRENEURSHIP	100	3	42
MSBT-402	IPR AND BIOSAFETY	100	3	42

**Paper (Practical) : 3 Papers = 300 Marks**

MSBT- 403	COMPREHENSIVE VIVA-VOCE	100	2	40 hrs
MSBT- 404	INDUSTRY / INSTITUTE VISIT AND FORMULATION OF A RESEARCH PROPOSAL / SEMINAR	100	2	40 hrs
MSBT-405	DISSERTATION (INDEPENDENT PROJECT WORK BASED ON ELECTIVE PAPER)	100	2	---

### List of Suggested Electives:

1. Pharmaceutical Biotechnology
2. Microbial Biotechnology
3. Agricultural Biotechnology
4. Environmental Biotechnology

^Any two 1.5 credit courses can be taken up to make one 3 credit course.  
Kindly visit the link - "Electives" on the main page for the contents of electives

# **M.Sc BIOTECHNOLOGY**

## **COURSE CONTENTS**

### **MSBT-101 : BIOPHYSICS AND 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, <sup>13</sup>C NMR spectra of proteins, <sup>31</sup>P NMR studies, NMR spectra of nucleic acids, Fourier transform of NMR spectroscopy, Relaxation (ID spectra)
- 6. X-Ray Crystallography** – Instrumentation, Fourier transformation, Application

#### **Text/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.
- 2. 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

**3. 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

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

**5. 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

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

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

### **Text/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 Rascriver, Arthur L. Beaudet, William S. Sly & David Valle : The Metabolic basis of inherited diseases

## **MSBT –102 : CELL AND DEVELOPMENTAL BIOLOGY**

**1. Cell Theory & Methods of Study** - Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc.

**2. Membrane Structure and Function** - Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata.

**3. Organelles** - Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

**4. Endo-membrane System and Cellular Motility** - Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals.

**5. Cellular Movements and Pattern Formation** - Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like Fucus and Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

**6. Differentiation of Specialized Cells** - Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in Salmonella; Mating cell types in yeast; Surface antigen changes in Trypanosomes; Heterocyst differentiation in Anabaena; Sex determination in Drosophila.

**7. Plant Meristem Organization and Differentiation** - Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes.

#### Texts/References:

1. Lodish *et al.*, **Molecular cell Biology**, 4th Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, **Cell Biology**, 2nd Edition, Chapman & Hall, London, 1996.
3. Watson *et al.*, **Molecular Biology of the gene**, 5<sup>th</sup> Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, **Chromatin & Gene regulation**, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, **Gene IX**, 9th Edition, Jones and Barlett Publishers, 2007.

## **MSBT-103 : MOLECULAR BIOLOGY**

**1. Genome organization** - Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA re-association kinetics(Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting.

**2. DNA Structure; Replication; Repair & Recombination** - Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photo-reactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

**3. Prokaryotic & Eukaryotic Transcription** - Prokaryotic Transcription; Transcription unit; Promoters - Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation – Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA, Eucaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

**4. Post Transcriptional Modifications** - Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

**5. Translation & Transport** - Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and Degradation.

**6. Mutations; Oncogenes and Tumor suppressor genes** - Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor

genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators and biological mutagens; Transposition - Transposable genetic

#### **Text/References:**

1. Benjamin Lewin, *Gene IX, 9th Edition*, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; *Molecular Biology of the Gene, 6th Edition*, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; *Molecular Biology of the Cell, 4th edition*, Garland, 2002.

## **MSBT-104 : ANALYTICAL TECHNIQUES**

1. **Basic Techniques** - Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques
2. **Spectroscopy Techniques** - UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy
3. **Chromatography Techniques** - TLC and Paper chromatography; Chromatographic methods for macromolecule separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity
4. **Electrophoretic techniques** - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis
5. **Centrifugation** - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.
6. **Radioactivity** - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay.
7. **Advanced Techniques** - Protein crystallization; Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis

#### **Texts/References :**

1. Freifelder D., *Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition*, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, *Principles and Techniques of Practical Biochemistry, 5th Edition*, Cambridge University Press, 2000.
3. D. Holme & H. Peck, *Analytical Biochemistry, 3rd Edition*, Longman, 1998.
4. R. Scopes, *Protein Purification - Principles & Practices, 3<sup>rd</sup> Edition*, Springer Verlag, 1994.
5. Selected readings from *Methods in Enzymology*, Academic Press.

## **MSBT-105 : BIOSTATISTICS & COMPUTER APPLICATION**

## **Biostatistics**

**1. Probability and Statistics** - Definition of Probability, Relative frequency, Probability distribution (Binomial, Poisson & normal), simple examples.

**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.

**2. Fundamental concepts in applied probability** - Exploratory data analysis and statistical inference; Probability and analysis of one and two way samples; discrete and continuous probability models; Expectation and variance; Central limit theorem; Inference; Hypothesis; Critical region and error probabilities; Tests for proportion; Equality of proportions; equality of means of normal populations (variance known, variance unknown); P-value of the statistic; Confidence limits; Introduction to one way and two-way analysis of variance; Data transformations.

## **Computer Application**

**1. 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. 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.

**3. 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. 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.

**5. 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.

**6. Elements of programming languages** - C and PERL; Data base concept; Database management system; Database browsing and Data retrieval; Sequence database and genome database; Data Structures and Databases; Databases such as GeneBank; EMBL; DDBJ; Swissplot; PIR; MIPS; TIGR; Hovergen; TAIR; PlasmoDB; ECDC; Searching for sequence database like FASTA and Blast algorithm.

**Texts/References:**

1. Wayne W. Daniel, *Biostatistics : A foundation for Analysis in the Health Sciences*, 8th Edition, Wiley, 2004.
2. Prem S. Mann, *Introductory Statistics*, 6th Edition, Wiley, 2006.
3. John A. Rice, *Mathematical Statistics and Data Analysis*, 3<sup>rd</sup> Edition, John A. Rice, Duxbury Press, 2006.
4. Campbell and Heyer, *Discovering Genomics, Proteomics, & Bioinformatics*, 2nd Edition, Benjamin Cummings, 2002.
5. Cynthia Gibas and Per Jambeck, *Developing Bioinformatics Computer Skill*, 1st Edition, O'Reilly Publication, 2001

## **PRACTICAL PAPERS**

### **MSBT-106 : LAB ON BIOPHYSICAL AND 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 :

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

### **MSBT- 107 : LAB ON CELL BIOLOGY, MICROSCOPY AND INSTRUMENTATION**

1. Microscopy & Imaging
2. Principles & Operation of General Equipment usually used in Research laboratories
3. General procedure for Tissue culture
4. Primary Cultures from Embryonic Tissue
5. Culture of specific Cell types
6. Cell separation techniques
7. Cytotoxic & Cell Growth Assays

#### References :

- (1) Barch M J et al; *The AGT Cytogenetics Laboratory Manual*; 3<sup>rd</sup> Ed, 1997; Lippincott-Raven; New York
- (2) Celis Julio; *Cell Biology – a laboratory manual*; AP; 2<sup>nd</sup> Ed, 1998.
- (3) Celis Julio; *Cell Biology – a laboratory manual*; AP; 2<sup>nd</sup> Ed, 1998.
- (4) *Culture of Animal Cells – a manual of basic techniques* : R Ian Freshney (Wiley Publication)

### **MSBT-108 : LAB ON MOLECULAR BIOLOGY**

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.

4. Agarose gel electrophoresis
3. Restriction Enzyme digestion of DNA
4. Purification of DNA from an agarose gel
5. DNA Ligation
6. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency
7. Cloning of genomic DNA in standard plasmid vectors
8. Confirmation of the insert, Miniprep of recombinant plasmid DNA Restriction mapping
9. Polymerase Chain reaction using standard primers
10. RFLP analysis of the PCR product
11. Transformation of yeast *Saccharomyces cerevisiae*

#### References :

**Sambrook & Russell : Molecular Cloning; 3<sup>rd</sup> Ed; 2001**

### **MSBT-109 : LAB ON ANALYTICAL TECHNIQUES**

1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. An Enzyme Purification theme (such as E.coli Alkaline phosphatase or any enzyme of the institutions choice).
  - (a) Preparation of cell-free lysates
  - (b) Ammonium Sulfate precipitation
  - (c) Ion-exchange Chromatography
  - (d) Gel Filtration
  - (e) Affinity Chromatography
  - (f) Generating a Purification Table
  - (g) Assessing purity by SDS-PAGE Gel Electrophoresis
  - h) Assessing purity by 2-D gel Electrophoresis
  - (i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

### **MSBT-110 : SEMINAR / JOURNAL CLUB**

#### **Seminar**

The seminars are on a topic scheduled for the semester. The topic is presented in depth appropriate for postgraduates by one of the M.Sc students and moderated by a faculty member.

The seminars represent only a small and somewhat arbitrary selection of topics. They are not intended to cover an entire subject. Their aims are to:

- (a) introduction about a special area
- (b) tune the students to the area
- (c) cover recent advances
- (d) give students practice in the art of oral presentation

#### **Journal Club**

The journal clubs are on an article belonging to a topic scheduled for the semester. The article is presented by an M.Sc./Ph.D. student or senior demonstrator, and moderated by a faculty member.

The aims of journal clubs are to:

- (a) highlight recent advances
- (b) discuss classical papers
- (c) inculcate the faculty of critical appreciation of a research article
- (d) give students and senior demonstrators practice in the art of oral presentation
- (e) Faculty presentations are usually on:

Research methodology and an area of research in which the faculty member is involved.

## **SECOND SEMESTER**

### **MSBT-201 : IMMUNOTECHNOLOGY**

**1. Introduction to Immunotechnology** - Kinetics of immune response, memory; Principles of Immunization; Techniques for analysis of Immune response

**2. Antibody Related Techniques** - Immuno-chemistry of Antigens - immunogenicity, Antigenicity, haptens, Toxins-Toxoids, Hapten-carrier system; Genetic basis of immune response; Role and properties of adjuvants, Immune modulators; B cell epitopes; Hybridoma Rabbit, human; Antigen–Antibody interaction, affinity, cross reactivity, specificity, epitope mapping; Immuno assays: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, Surface plasma resonance, Biosensor assays for assessing ligand–receptor interaction

**3. New Generation Antibodies** - Multigene organization of immunoglobulin genes, Ab diversity; Antibody engineering; Phage display libraries; Antibodies as in vitro and in vivo probes

**4. CMI and Imaging techniques** - CD nomenclature, Identification of immune Cells; Principle of Immunofluorescence Microscopy, Fluorochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Cell Functional Assays – lymphoproliferation, Cell Cytotoxicity, Mixed Lymphocyte Reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, In-situ gene expression techniques; Cell imaging Techniques- *In vitro* and *In vivo*; Immuno-electron microscopy; *In vivo* cell tracking techniques; Microarrays; Transgenic mice, gene knock outs.

**5. Vaccine technology** - Rationale vaccine design based on clinical requirements; Hypersensitivity, Immunity to Infection, Autoimmunity, Transplantation, Tumor immunology, immunodeficiency; Active immunization; Live, killed, attenuated and Sub unit vaccines; Recombinant DNA and protein based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines; Passive Immunization; Antibody, Transfusion of immuno-competent cells, Stem cell therapy; Cell based vaccines.

#### **Texts/References:**

1. F.C. Hay, O.M.R. Westwood, **Practical Immunology, 4th Edition, Blackwell Publishing, 2002**
2. S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, **Selected Methods for Antibody and Nucleic Acid probes, Volume1, Cold Spring Harbor Laboratory Press,1993.**
3. Ed Harlow, David Lane, **Antibodies Laboratory Manual, Cold Spring Harbor, Laboratory Press, 1988.**

### **MSBT-202 : MICROBIOLOGY & INDUSTRIAL APPLICATION**

**1. Microbial Diversity & Systematics** - Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Classification of Bacteria according to Bergey's manual; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project.

**2. Microbial Growth & Physiology** - Ultrastructure of Archaea (Methanococcus); Eubacteria (*E.coli*); Unicellular Eukaryotes (Yeast) and viruses (Bacterial, Plant, Animal and Tumor viruses); Microbial growth: Batch, fed-batch,

continuous kinetics, synchronous growth, yield constants methods of growth estimation, stringent response, death of a bacterial cell. Microbial physiology: Physiological adaptation and life style of Prokaryotes; Unicellular Eukaryotes and the Extremophiles (with classical example from each group)

**3. Microbial Interactions and Infection** - Host-Pathogen interactions; Microbes infecting humans, veterinary animals and plants; Pathogenicity islands and their role in bacterial virulence.

**4. Microbes and Environment** - Role of microorganisms in natural system and artificial system; Influence of Microbes on the Earth's Environment and Inhabitants; Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing; Microbial fuel cells; Prebiotics and Probiotics; Vaccines

**5. Industrial Applications** - Basic principles in bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Batch and continuous sterilization systems; Primary and secondary metabolites; Extracellular enzymes; Biotechnologically important intracellular products; exopolymers; Bioprocess control and monitoring variables such as temperature, agitation, pressure, Ph Microbial processes-production, optimization, screening, strain improvement, factors affecting down stream processing and recovery; Representative examples of ethanol, organic acids, antibiotics etc., Enzyme Technology-production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilised Enzyme and Cell based biotransformations-steroids, antibiotics, alkaloids, enzyme/cell electrodes.

#### **Texts/References:**

1. Pelczar MJ Jr., Chan ECS and Kreig NR., *Microbiology, 5th Edition, Tata McGraw Hill, 1993.*
2. Maloy SR, Cronan JE Jr., and Freifelder D, *Microbial Genetics, Jones Bartlett Publishers, Sudbury, Massachusetts, 2006.*
3. Crueger and A Crueger, (English Ed., TDW Brock); *Biotechnology: A textbook of Industrial Microbiology, Sinauer Associates, 1990.*
4. G Reed, Prescott and Dunn's, *Industrial Microbiology, 4th Edition, CBS Publishers, 1987.*
5. M.T. Madigan and J.M. Martinko, *Biology of Microorganisms, 11<sup>th</sup> Edition, Pearson Prentice Hall, USA, 2006.*

## **MSBT-203 : GENETIC ENGINEERING**

**1. Basics Concepts** - DNA Structure and properties; Restriction Enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay

**2. Cloning Vectors** - Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; EMBL; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/baculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors.

**3. Cloning Methodologies** - Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Farwestern cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression.

**4. PCR and Its Applications** - Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

**5. Sequencing methods** - Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knock out mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array.

#### **Text/References:**

1. S.B. Primrose, R.M. Twyman and R.W.Old; **Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.**
2. J. Sambrook and D.W. Russel; **Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.**
3. Brown TA, **Genomes, 3rd ed. Garland Science 2006**
4. **Selected papers from scientific journals.**
5. **Technical Literature from Stratagene, Promega, Novagen, NewEngland Biolab etc**

## **MSBT-204 : GENETICS**

**1. Bacterial mutants and mutations** - Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant); Mutation rate; Types of mutations(base pair changes; frameshift; insertions; deletions; tandem duplication); Reversionvs. suppression; Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test)

**2. Gene transfer in bacteria** - History; Transduction – generalized and specialized; Conjugation – F, F', Hfr; F transfer; Hfr-mediated chromosome transfer; Transformation – natural and artificial transformation; Merodiploid generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons.

**3. Bacteriophages and Plasmids** - Bacteriophage–structure; Assay; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology - copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid.

**4. Restriction-modification systems** - History; Types of systems and their characteristics; Methylation dependent restriction systems; applications.

**5. Mendelian Genetics** - Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Complicating factors – incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases.

**6. Non-Mendelian inheritance patterns** - Mitochondrial inheritance; Genomic imprinting; Lyon hypothesis; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits

**7. Cyto-genetics**

Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).

**8. Developmental Genetics** - Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; Signaling and adhesion molecules.

**9. Immunogenetics** - Major histocompatibility complex; Immunoglobulin genes - tissue antigen and organ transplantation; Single gene disorders of immune system.

**10. Genetic variation** - Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism.

**11. Gene mapping and human genome project** - Physical mapping; linkage and association

**12. Population Genetics and Evolution** - Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift; Human genetic diversity; Origin of major human groups.

#### Texts/References:

1. S.R. Maloy, J.E. Cronan, D. Friefelder, *Microbial Genetics*, 2<sup>nd</sup> Edition, Jones and Bartlett Publishers, 1994.
2. N. Trun and J. Trempy, *Fundamental Bacterial Genetics*, Blackwell publishing, 2004.
3. Strachan T and Read A P, *Human molecular genetics*, 3rd Edition Wiley Bios, 2006.
4. Mange E J and Mange A. P., *Human genetics*, 2nd Edition, Sinauer Associates publications, 1999.
5. Hartl L D and Jones B, *Analysis of genes and genomes*, 3rd Edition, Jones and Bartlett Publishers, 1994.

## **MSBT-205 : GENOMICS AND PROTEOMICS**

**1. Introduction** - Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

**2. Genome sequencing projects** - Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, EST's and SNP's, Large scale genome sequencing strategies, Genome assembly and annotation, Prediction of Genes, Promoters, Splice sites, Gene networks.

**3. Proteomics** - Protein analysis (includes measurement of concentration, aminoacid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution iso-electric focusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system

**4. Pharmacogenetics** - High throughput screening in genome for drug discovery identification of gene targets, Pharmaco-genetics and drug development

**5. Structural (SG) & Functional Genomics (FG)** - the need for SG, basic principles, approaches for target selection, 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.

**6. Proteomics** - 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.

#### **Texts/References:**

1. Voet D, Voet JG & Pratt CW, **Fundamentals of Biochemistry, 2<sup>nd</sup> Edition. Wiley 2006**
2. Brown TA, **Genomes, 3rd Edition. Garland Science 2006**
3. Campbell AM & Heyer LJ, **Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007**
4. Primrose S & Twyman R, **Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.**
5. Glick BR & Pasternak JJ, **Molecular Biotechnology, 3rd Edition, ASM Press, 1998.**

## **PRACTICALS**

### **MSBT - 206 : LAB ON IMMUNOLOGY**

1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.
2. Antibody Titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays
7. Blood smear identification of leucocytes by Giemsa stain
8. Separation of leucocytes by dextran method
9. Demonstration of Phagocytosis of latex beads
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Lymphoproliferation by mitogen / antigen induced
12. Immunodiagnosics using commercial kits

### **MSBT-207 : LAB ON MICROBIOLOGY**

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

### **MSBT-208 : LAB ON GENETIC ENGINEERING**

1. Isolation of genomic DNA from *Bacillus subtilis*\* genome.
2. PCR amplification of *scoC* gene and analysis by agarose gel electrophoresis
3. Preparation of plasmid, pET-28a from *E.coli* DH5 $\alpha$  and gel analysis.

4. Restriction digestion of vector (gel analysis) and insert with Nco I and Xho I
5. a. Vector and Insert ligation
- b. Transformation in E.coli DH5 $\alpha$ .
6. Plasmid isolation and confirming recombinant by PCR and RE digestion.
7. Transformation of recombinant plasmid in BL21 (DE3).
8. Induction of ScoC protein with IPTG and analysis on SDS-PAGE
9. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE
10. a. Random Primer labeling of scoC with Dig-11-dUTP
- b. Southern hybridization of B. subtilis genome with probe and non-radioactive detection.

\*Any other bacterial strain can be used.

## **MSBT-209 : LAB ON COMPUTER APPLICATION OF GENOMICS AND PROTEOMICS**

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- Merge, 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.

### **Protein Structure predicting:**

Higher order protein structure. Ramachandran plot. Classification of functional part of the protein.  
 Elementary idea on crystallography and NMR spectroscopy.  
 Homology modeling software SWISS modeling.  
 Representation of protein structure in a computer file.  
 Protein structure prediction algorithms of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation methods. Ab-initio structure prediction.  
 Application of Chou-fasman and GOR algorithm, use of PSSM.  
 Computational problems related to protein structure. CATH, SCOP

### **Molecular modeling:**

Concept of stereo chemistry, conformation and configuration,  
 Calculation of Energies of bio molecules, Modes of vibration of a molecules, Idea experimental approaches to modeling from NMR data,  
 Energy minimization and several algorithm of energy minimization. Molecular visualization software.  
 Introduction to MD simulation.  
 Introduction to GROMACS software. Algorithms and parameters.

## **MSBT-210 : SEMINAR / JOURNAL CLUB**

### **Seminar**

The seminars are on a topic scheduled for the semester. The topic is presented in depth appropriate for postgraduates by one of the M.Sc students and moderated by a faculty member.

The seminars represent only a small and somewhat arbitrary selection of topics. They are not intended to cover an entire subject. Their aims are to:

- (a) introduction about a special area
- (b) tune the students to the area
- (c) cover recent advances
- (d) give students practice in the art of oral presentation

### **Journal Club**

The journal clubs are on an article belonging to a topic scheduled for the semester. The article is presented by an M.Sc./Ph.D. student or senior demonstrator, and moderated by a faculty member.

The aims of journal clubs are to:

- (a) highlight recent advances
- (b) discuss classical papers
- (c) inculcate the faculty of critical appreciation of a research article
- (d) give students and senior demonstrators practice in the art of oral presentation
- (e) Faculty presentations are usually on:

Research methodology and an area of research in which the faculty member is involved

## **THIRD SEMESTER**

### **MSBT-301 : BIOPROCESS ENGINEERING AND INDUSTRIAL APPLICATION**

**1. Basic principle of Biochemical Engineering** - Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

**2. Concepts of basic mode of fermentation processes** - Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

**3. Downstream processing** - Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra-filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

**4. Applications of enzymes in food processing** - Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Inter-esterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

**5. Applications of Microbes in food process operations and production** - Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

**6. Enzyme kinetics** - Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

#### **Texts/ References:**

1. Jackson AT., **Bioprocess Engineering in Biotechnology**, Prentice Hall, Engelwood Cliffs, 1991.
2. Shuler ML and Kargi F., **Bioprocess Engineering: Basic concepts** 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
3. Stanbury RF and Whitaker A., **Principles of Fermentation Technology**, Pergamon press, Oxford, 1997.
4. Baily JE and Ollis DF., **Biochemical Engineering fundamentals**, 2nd Edition, McGraw-Hill Book Co., New York, 1986.
5. Aiba S, Humphrey AE and Millis NF, **Biochemical Engineering**, 2nd Edition, University of Tokyo press, Tokyo, 1973.
6. **Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine**, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
7. Mansi EMTEL, Bryle CFA. **Fermentation Microbiology and Biotechnology**, 2nd Edition, Taylor & Francis Ltd, UK, 2007.

## **MSBT-302 : BIOINFORMATICS**

**1. Bioinformatics Algorithms and Tools** - Publicly available databases; Visualisation of sequence data; Sequence alignment; Homology searching - including BLAST; Gene expression informatics; Introduction to gene finding

**2. Molecular Modeling, Drug designing and Chemo-informatics** - Acquisition of chemical information - including molecular structures - from databases; Visualisation of molecules; Simulation of molecular interactions; Introduction to industry-standard modeling software. Energy Optimization techniques: golden section method, parabolic interpolation, conjugate gradient, Raphson, genetic algorithm; Structure based drug designing, locating binding sites in protein structure, SMILES- Simplified Molecular Input Line Entry System.

**3. Structural Bioinformatics** - Protein structures, Ramchandran plot, protein folding structure function relationship, conformational energy calculations, protein structure predictions, secondary and tertiary, protein structure classification-SCOP, CATH, Immuno-informatics-epitope prediction

**4. Bioinformatics: The Business of Research** - Research methodology (focusing on computer-based research); Case studies of areas of current bioinformatics research; Routes to research funding (academic and commercial); Bioinformatics business models

**5. Introduction to following DATABASES & Tools** - GenBank, Entrez, Introduction to NCBI Protein and Nucleotide Database, OMIM, PubMed, ExPasy server search tools and Databases, PIR, Swissprot, TrEmble, PROSITE, PDB, NDB, KEGG, Complex Carbohydrate Structure Database (CCSD), Molecular visualizing tool (Rasmol, Molmol), Gromacs.

## **MSBT- 303 : FOOD SCIENCE & BIOTECHNOLOGY**

**1. Principles of food processing** : Scope and importance of food processing. National and international perspectives, Principles and methods of food preservation-freezing, heating, dehydration, canning, additives, fermentation, irradiation, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, aseptic processing, hurdle technology, Juices and concentrates/membrane technology, Storage of food, modified atmosphere packaging. Refrigeration, freezing and drying of food, minimal processing, radiation processing.

**2. Food microbiology** : History of microbiology of food, Microbial growth pattern, physical and chemical factors influencing destruction of micro-organisms. Types of micro-organism normally associated with food-mold, yeast, and bacteria. Micro-organisms in natural food products and their control, Contaminants of foods-stuffs, vegetables, cereals, pulses, oilseeds, milk and meat during handling and processing, Biochemical changes caused by micro-organisms, deterioration of various types of food product, Food poisoning and microbial toxins, microbial food fermentation, standards for different foods, Food borne intoxicants and mycotoxins.

**3. Food chemistry** : Definition and importance, water in food, water activity and shelf life of food, Carbohydrates-chemical reactions, functional properties of sugars and polysaccharides in foods, Lipids: classification, and use of lipids in foods, physical and chemical properties, effects of processing on functional properties and nutritive value,

Protein and amino acids: physical and chemical properties, distribution, amount and functions of proteins in foods, functional properties, effect of processing, Losses of vitamins and minerals due to processing, Pigments in food, food flavours, browning reaction in foods, Enzymes in foods, and food industry, bio-deterioration of foods, food contaminants, additives and toxicants.

**4. Food quality assurance** : Objectives, importance and functions of quality control, Methods of quality, concepts of rheology, assessment of food materials-fruits, vegetables, cereals, dairy products, meat, poultry, egg and processed food products, Sampling and specification of raw materials and finished products, statistical quality control, Food regulations, grades and standards, Concept of Codex Alimentarius/HACCP/USFDA/ISO 9000 series etc., Food adulteration and food safety, Sensory evaluation-introduction, panel screening, selection methods, Interaction and thresholds, Sensory and instrumental analysis in quality control, Food laws and standards.

**5. Food packaging** : Introduction to packaging, Packaging operation, package-functions and design, Principle in the development of protective packaging, Deteriorative changes in foodstuff and packaging methods for

prevention, shelf life of packaged foodstuff, methods to extend shelf-life, Food containers-rigid containers, corrosion of containers (Tin plate), Flexible packaging materials and their properties, Food packaging materials and their properties, Food packages-bags, pouches, wrappers, carton and other traditional package, Biodegradable packaging.

**6. Food biotechnology :** History and development of biotechnology, Application of genetics to food production, Principles of down stream processing, small, medium and large scale processing, Bacterial starter culture, Methods of inoculum, and medium preparation, slurry processing and product isolation, Technological aspects of industrial production of beer, wine, enzymes amylase, pectinase, proteases, organic acids, amino acids, vitamins, antibiotics, baker's yeast, single cell protein, Fermented food: origin, scope and development, Regulatory and social aspects of biotechnology of foods, application of enzymes in food industry, production of food flavour, colour, enzymes, Immobilised enzymes.

**7. Post-harvest technology :** Post harvest technology of horticultural crops, post-harvest losses of fruits & vegetables, control of post-harvest losses, post-harvest packaging.

**8. Advanced techniques of food analysis :** Role of analysis, and various methods of sampling, analysis of results, Principles and application in flame photometry and atomic absorption, Colour of foods and its measurement, X-ray analysis of foods and its applications, electrophoresis-applications, principle and different types.

## Electives Papers:

### MSBT(PBT)-304 : Pharmaceutical Biotechnology-I

1. **Molecular Function of Nucleic Acid and Protein** (Flow of Genetic Information): Nucleic acid, Polypeptide and protein, transcription and translation in prokaryotes and eukaryotes, Role of transcription and translation in molecular biotechnology.
2. **Replication and Polymerase Chain Reaction :** Replication in prokaryotes and eukaryotes, Basic principles of Polymerase Chain Reaction (PCR) , modified PCR
3. **Recombinant DNA Technology :** Basic principle of Recombinant DNA Technology, Vectors ; cloning and expression of vectors ; ligation, transformation and clone characterization ; Using recombinant DNA technology in Biotechnology.
4. **Molecular Biotechnology :** Creation of new strains / mutants rather than isolation , screening of strains from nature ; Cells , Plants, Animals used as biological factories.
5. **Manipulation of Gene Expression :** Use of expression vectors , strategy of overproduction, selection of vectors, selection of cells.
6. **Therapeutic Protein, Vaccines and Technology to produce recombinant proteins :** Prokaryotic and

Eukaryotic system ( lower and higher), therapeutic proteins and vaccines.

7. **Monoclonal Antibody and Technology to produce monoclonal antibodies** ; Hybridoma technology and Recombinant technology to produce monoclonal antibody, monoclonal antibodies for therapeutic purpose and their mode of action

## **MSBT(MBT)-304 : Microbial Biotechnology - I**

### **Microbial Biotechnology in Industry**

- 1. Introduction to Industrial Microbiology**- An historical perspective and microbial community
- 2. Technology of Microbial cell maintenance** – Sample collection strategies and Culture characterisation by physical, immunological and nucleic acid based, strain improvement by mutation of gene transfer processes, steps to maintain microbial culture, Strain preservation,
- 3. Bioprocessing technology**- Types of Bioreactors, A conventional bioreactor – common features, Fermenters (Stirred tank, bubble columns, airlift. bioreactors, limitations of bioreactors, , Media design and sterilisation for fermentation processes, stages of fermentation processes Solid substrate fermentation, Static, Submerged and agitated fermentation, advantages & disadvantages Metabolic products, Scale up, Yield and Yield Coefficient
- 4. Downstream processing** – solid liquid separations, product precipitation extraction, separation, concentration, evaporation recovery purification & formulation.
- 5. Microbial production** - Industrial production of Ethyl alcohol, Acetone butanol. Vinegar, Citric acid, lactic acid, L ascorbic acids,  $\alpha$ -amylase, protease penicillin, cephalosporine tetracycline griseofulvin,  $\beta$  carotene and vitamin B<sub>12</sub>, Insulin. Polysaccharides, PHA/B, rubber and adhesives.
- 6. Biotransformation** - Types and examples of biotransformation, techniques, catalysts and product recovery of steroids, antibiotics, prostaglandins, dihydroxyacetone and indigo.

**7. Enzyme technology** – Commercial production of enzymes, Immobilisation of enzymes and cells. Methods choice applications and limitations of microbial cells used as catalysts in fermentation, multi-enzyme reactors, Industrial applications of immobilized enzymes as biosensor and therapeutic purpose.

## Microbial Biotechnology in Medicine

**1. Introduction to Microbes in therapeutic purpose** - An historical perspective, Application of Recombinant Microorganisms in Medicine

**2. Microbial DNA in Disease Diagnosis** – TB, Malaria, AIDs, Cystic fibrosis, HPV, Lyme disease

**3. Pharmaceutical products** - Human proteins - Insulin, HGH, Clotting factor VIII, TPA, Interferons, Alginate Lyase,

**4. Recombinant vaccines**- subunit vaccines, Hepatitis B, FMD, HSV, TB, AIDS, RNA Vaccines, Edible vaccines, Attenuated vaccines, Cholera, Salmonella, Leishmania Vector recombinant vaccines - Vaccinia virus, Antigen delivery by bacteria.

**5. Monoclonal antibodies**- production Mab in E.coli, second generation Mab, Advantages and disadvantages of Mab Application in disease diagnosis and therapeutic agent, Protein purification, Catalytic Mabs.

## MSBT(ABT)-304 : Agricultural Biotechnology-I

**1. Basics of Agriculture and Plant Breeding** - Factors affecting agriculture and agricultural classification of plants, Methods of breeding of self-pollinated and vegetatively-propagated plants, Breeding of crops pollinated plants – Hybridization and pest hybridization selection methods – synthetic varieties. Heterosis – Genetic and Molecular basis. Apomixis – Mechanism and significance in crop improvement. Mutations – Molecular basis and use in crop improvement.

**2. Tissue Culture (Basic concept of plant in vitro technology)** - Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect embryogenesis; Cell suspension culture.

Micropropagation – shoot tip culture, somatic embryos, artificial seeds; Applications of tissue culture; Virus elimination by shoot tip culture; Wide hybridization and embryo culture; Anther culture and dihaploids.

Large-scale cell suspension culture; Production of alkaloids and other secondary metabolites; Protoplast culture, Plant cell wall structure and cell wall hydrolyzing enzymes; Protoplast isolation and purification; Protoplast viability test; Protoplast culture; Protoplast fusion; Somatic hybrids; Cybrids.

**3. Somatic cell genetics** - Somaclonal variation; Genotypic and Phenotypic variations in cell cultures and in regenerated plants, Origin; Types; chromosomal and genetic basis of somaclonal variation; Applications in crop improvement.

**4. Germplasm preservation** - Concept of Biodiversity and role of *in situ* and *ex situ* conservations of germplasms; Cryo-preservation; Principle, Techniques and Applications.

**5. Bioreactors:** concept, types and use in plant tissue culture

**6. Genetic manipulations in plants** - Strategies and Methods of genetic manipulations in plants; Achievements and recent developments of genetic engineering in agriculture, *Agrobacterium*-mediated gene transfer; Genetic elements and engineering of Ti and Ri plasmids; Direct gene transfer – electroporation, particle bombardment and other alternative methods; Role of markers in plant transformation; Application of plant transformation for

productivity and performance; Molecular farming, benefits and risks; Transgene stability and gene silencing; Strategies to avoid gene silencing and improve gene expression in transgenic plants.

**7. Production of secondary metabolites by cell and organ cultures** - Secondary product formation and storage in plants, Manipulation of biosynthetic capacity of secondary metabolites in cell cultures; factors determining the accumulation of secondary metabolites by plant cells and organ cultures; strategies for improvement of metabolite production; Screening and selection of variant cell lines with increased secondary product level. Biotransformation using plant cell cultures; Transformed cell and root cultures for production of secondary metabolites ; Metabolic engineering for production of secondary metabolites. Commercial applications.

**8. Soil science and agricultural chemistry:** Soil as a medium of plant growth and its composition; mineral and organic constituents of soil and their role in crop production; chemical physical and microbiological properties of soil; essential plant nutrients, their functions occurrence and recycling; micro-secondary and micro nutrient sources and their management; integrated nutrient management, soil water relationship, principles of soil fertility and its evaluation for judicious use of fertilizers; organic manure and bio-fertilizers; soil conservation planning on water shed basis; erosion and run-off management in hilly, foot hills and valley lands; processes and factors affecting soil erosion; dry land agriculture and its problems; rain fed agriculture.

## **MSBT(EBT)-304 : Environmental Biotechnology - I**

### **Environmental Biology**

**1. The environment** - Definition, components and structures.

**2. 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).

**3. Ecophysiology** - Ecophysiology of plants & animals, Ecological Health. Environmental impacts on respiration and Circulation, Nervous Systems ,Muscles, and Chemical messengers of human. Levels and Fundamental Mechanisms of Adaptation,

**4. Community classification** - Community structure & and associations between species, Diversity indices, hierarchical classification.

**5. Environmental 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.

**6. Ecological sampling theory** - sample sizes, locations of sampling effort, methods of sampling.

**7. Restoration ecology** - Rationale for Restoration, Approaches, Focuses of Conservation Biology and Restoration Ecology, Ethical Considerations. Natural resource conservation and their management.

### **Environment and Environmental Pollution**

**1. Composition and chemistry of Environment** - Earth atmosphere, Aquatic environments, Terrestrial environments, Environmental indicators.

**2. Air pollution** – Definition, Pollutants, Sources of air pollution, Air Quality Index, Atmospheric dispersion modelling, Indoor air quality (IAQ), Acid rain, Chlorofluorocarbon, Ozone depletion, Particulate, Green House gases, CO<sub>x</sub>, NO<sub>x</sub>, VOC, SO<sub>2</sub>, Mercury, Dioxin and furan, photochemical Smog, Health effects.

**3. Water pollution** - Definition, Nonpoint sources, Water quality indicators, Particulate matters, Metals, Plastics, Wastes Eutrophication, Hypoxia, Marine pollution, Ocean acidification, Oil spill, Ship pollution, Soil Surface runoff, Thermal pollution, Waste water, Waterborne diseases, Water quality, Water stagnation.

**4. Soil Pollution** – Definition, pollution by Herbicide & Pesticide, fungicides, Trace element, chemical contamination, Soil Guideline Values – SGVs.

**5. 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.

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

**7. Biopollution** – pollen grains, fungal spore Vegetables, municipal waste solid waste, Biological Weapons.

**8. Global warming and Major organizations & Inter-government treaties** – Global Atmosphere Watch, Green house effect, Ozone problem and consequences, National Ambient Air Quality Standards, Montreal Protocol, Nitrogen Oxide Protocol, Kyoto Protocol, CLRTAP, DEFRA, EPA.

**9. Control of Pollution** - Pollution monitoring & environmental management . toxicity testing, regulating hazardous materials, Environmental risk assessment.

**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.

## **MSBT(PBT)-305 : Pharmaceutical Biotechnology - II**

**1. Protein Isolation and Purification** : Strategy for proteins isolation for intracellular and extracellular proteins, strategies for recombinant proteins purification (gel filtration, ion exchange, reverse phase, affinity, hydrophobic interaction chromatographies)

**2. Analysis of Recombinant Product** : Protein based analysis : determination of protein concentration, amino acids sequencing, peptide mapping, electrophoresis (SDS-PAGE, native PAGE, electro-focusing, two-dimensional electrophoresis), Western blot, DNA based analysis, Sequencing, Hybridization.

**3. Gene Therapy** : Explanation, Strategy and Principle of gene therapy (*in vivo and ex vivo*), Aim of Gene Therapy, Example of Gene Therapy.

**4. Transgenic Plant** : Explanation of transgenic plant, principle of construction of transgenic plant, use of transgenic plant, example of transgenic plant.

**5. Biosimilar Products** : Definition ; Regulation ; patent situation, First generation of biosimilar products ; EPO, CSFs, bGH, insulin, hepatitis B vaccines, factor VIII, IFN; development of biosimilar and its requirements.

**6. Formulation Recombinants Proteins :** General consideration protein and peptide formulation, routes of protein and peptide administration, excipients in protein and peptide formulation, quality control of final products.

**7. Targeted-drug delivery system :** Definition of conventional and targeted drug delivery system, type of targeted drug delivery system, urgency and aim of drug targeting, ligand, homing device, and homing molecule, design of targeted drug, mechanism of drug targeting.

**8. Tissue Engineering :** Tissue engineering as an alternative to organ transplantation, advantages of tissue engineering compared to other therapy, basic principle of tissue engineering, main component of tissue engineering

## **MSBT(MBT)-305 : Microbial Biotechnology - II**

### **Microbial Biotechnology in Agriculture**

**1. Microbes in the Terrestrial Environment –** General characteristics of porous media, Distribution of microbes in different soil zones and their metabolic states, role of microbes in surface soil formation, nutrients cycling, Soil pathogens and diseases in plant and human.

**2. Microorganisms and Agriculture –** Functions of Microorganisms: Putrefaction, Fermentation, and Synthesis, Relationships Between Putrefaction, Fermentation, and Synthesis of biomolecules Classification of Soils Based on the Functions of Microorganisms (Disease-Inducing Soils, Disease-Suppressive Soils, Zymogenic Soils, Synthetic Soils), Controlling the Soil Microflora for Optimum Crop Production and Protection.

**3. Microbial Metabolism -** Conversion of light energy into chemical bond energy-Photosystems I & II. production of ATP Cyano-bacteria and green algae. Role of bacterio-chlorophyll phycocyanin, phycoerythrin and carotenoids in photosynthetic bacteria and chlorophylls in green algae. Photosynthesis in anaerobic and sulphur bacteria. Biological N<sub>2</sub>-fixation by Free living anaerobic (*Clostridium*), facultatively anaerobic (*Azospirillum*) and aerobic (*Azotobacter*), N<sub>2</sub>-fixers associated with stem, root and leaf, Symbiotic N<sub>2</sub>-fixation in legumes and non- legumes by *Rhizobium* and *Frankia*, N<sub>2</sub>-fixation by cyanobacteria. Requirement of ATP, O<sub>2</sub>-sensitivity and inhibition by ammonia and nitrogenous substance in the case of nitrogenase, The peculiarity of alternate nitrogenase of *Streptomyces thermoautotrophicus*,

**4. Brief account of microbial interactions -**Symbiosis, neutralism, Commensalism, Competition, Ammensalism, Synergism, Parasitism.

**5. 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<sub>2</sub> and N<sub>2</sub>O (a green house gas) by denitrifying bacteria, free living and in association with *Azolla*, Phosphate solubilizing bacteria. Soil anaerobic methanogens in rice field, Effect of soil pH and heavy metals on microorganisms, Microbial antagonism in soil, Biological control of soil-borne microbial pathogens

**6. Application of Recombinant Microorganisms in Agriculture-** Agrobacterium and virus mediated gene transfer and improvements of crops

**7. Eco-friendly Microbes and their utilisation –**Utilization of beneficial Microorganisms in Agriculture, Ice minus bacteria and microbial pesticides

**8. EM Technology -** Effective Micro-organisms, EM-BOKASHI, EM-COMPOST, EM-5, EM-X, Recycling

## Microbial Biotechnology in Environment

- 1. Introduction to Environmental Microbiology**- An historical perspective and microbial ecology
- 2. Bioremediation** - Overview and applications, Bioindicators, Biosensors, Advantages and disadvantages of bioremediation ,
- 3. Bioremediation of Waste Water** - Importance of waste water, Biological Processes for Industrial Effluent Treatment, Aerobic Biological Treatment, Anaerobic Biological Treatment, Periodic Biological Reactors, Use of Immobilized Enzymes and Microbial Cells.
- 4. Bioremediation for Hazardous Waste Management** –Xenobiotic Compounds, Recalcitrance, , Hazardous Wastes, Bioaugmentation, Biosorption of Heavy metals, Biodegradation of Xenobiotics, Biological Detoxification of oil spills, Bio applications to Hazardous Waste Management,
- 5. Biomining**, Pyro and hydrometallurgy, Bioleaching , biooxidation, types and mechanism, Microbes in biomining, Phytomining
- 6. Bioremediation for Air Pollution Abatement and Odour Control** - Deodorization Process, Applications.
- 7. Biofertilisers** - Groups of biofertilisers, Microbial inoculants of nitrogen fixation, Vermicompost and Phosphocompost, Methods of production technologies
- 8. Biopesticides**- Insect resistance, herbicide resistance, Resistance against Bacteria viruses and fungi,
- 9. Bioenergy**- Energy conservation, energy development, alternative energy sources to reduce the impact of environmental pollution, Types and generations of bioenergy, Different production methods of bioenergy, Solar power - Solar cell & Solar heating
- 10. Separation technology applicable in Environmental Biotechnology** - Types of separation technology, MBST and their cost effective application, Physico-chemical properties of membrane, Different membrane modules and their applications in Biotechnology and Food industries

### Recommended Texts :

1. Biotechnology in Environmental Management/edited by G.R. Pathade and P.K. Goel. Jaipur, ABD, 2004
2. Environmental Biotechnology A.K. Parihar
3. "Waste water Engineering Treatment and Disposal and Reuse" by Metcalf & Eddy.
4. Biotechnology U Satyanarayan
5. Biotechnology B.D. Sing
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

## MSBT(ABT)-305 : Agricultural Biotechnology-II

- 1. Plant Physiology and Stress Biology** - Review of plant cell structure and function; Review of water uptake; Introduction to plant nutrition; Mineral availability- uptake of minerals; Plant response to nutrients : -
- 2. 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).

**3. 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.

Introduction to light - properties and responses – Photoperiodism; Canopy response to light – Canopy closure and yield potential - Red and Far Red light –Photomorphogeneis, Phytochrome responses, Blue light responses.

**4. Abiotic stress** – Acclimation and crop adaptation to water stress – salinity stress – temperature stress – heat and cold – Photo oxidative stress – nutrient stress – heavy metal stress – stress signaling - metabolite engineering for abiotic stress tolerance – functional genomics of stress tolerance.

**5. Biotic stress** - plant response to pathogens and herbivores – biochemical and molecular basis of host plant resistance – toxins of fungi and bacteria – systemic and induced resistance – pathogen derived resistance – signaling - gene for gene hypothesis – genetic engineering for biotic stress resistance – gene pyramiding, Development of transgenics for biotic and abiotic stress tolerance.

**6. Crop Protection and Integrated Pest Management** - Diseases of field, vegetable, orchard and plantation crops of India and their control; causes and classification of plant diseases; principles of plant disease control biological control of diseases; seed health testing, Integrated pest management-concepts and components; host plant resistance-biological control of insect pests; genetic manipulation of insects for their control; pesticides, their formulation, classification and safe use; behavioural methods; use of computer modeling in pest and disease out break; use of semiochemicals in IPM; insect growth regulators; biotechnological approaches in IPM; IPM in major crops, Principles of nematode management-integrated nematode management in major crops-silkworm types; mulberry silkworm, culturing methods; pests and diseases of mulberry and mulberry silkworm and their management.

**7. Animal Husbandry and Veterinary science** - Importance of livestock in agriculture; relationship between plant and animal husbandry; mixed farming; animal breeding; breeds of indigenous and exotic cattle, buffaloes, goats, sheep, pigs and poultries and their potential for milk, egg, meat and wool production; classification of feed and fodder; major contagious diseases affecting cattle and drought animals, poultries and pigs; reproduction biology of cattle.

**8. Seed technology** - Seed technology and its importance; production processing and testing of seeds of crop plants; seed storage, seed certification; role of NSC in production; new seed policy and seed control order, terminator technology.

**9. Agriculture Microbiology** - Microbes of agricultural importance : Prokaryotes: Bacteria, Cyanobacteria and viruses-general form, growth and reproduction. Culture of bacteria and viruses; identification of auxotrophic mutants for genetic analysis. Eukaryotes: Protozoa, Nematodes, Algae and Fungi, Genomes and genes of Microbes: Genome and extra genomic elements of bacteria. Genes in extragenomic elements. Genome of viruses-cos sites and their role in packaging. Genes involved in Lytic and Lysogenic cycles. Genomes of algae, fungi and protozoa. Genome sizes of economically important organisms and status of sequence information.

**10. Microbe based biofertilizers** - Cyanobacterial biofertilizers. Azolla and Anabena symbiotic association. Bacteria (Rhizobium) biofertilizers, Fungal (Mycorhiza) bio-fertilizers. Nitrogen fixation-asyymbiotic and symbiotic, nodule formation. Genetics and biochemistry of nitrogen fixation. Nif genes. Transfer of nif genes. Soil microbes releasing plant growth substances.

**11. Agriculture and microorganism** – 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.

**EM Technology** - Effective Micro-organisms, EM-BOKASHI, EM-COMPOST, EM-5, EM-X, Recycling. Agricultural waste treatment.

### **Recommended Texts :**

1. R.H.Smith, Plant Tissue Culture: Techniques and Experiments, Academic Press, San Diego. 1992.
2. B.B. Buchanan, W. Gruissen and R.L. Jones (eds), Biochemistry and Molecular Biology of Plants, American Society of Plant Biology, Rockville, USA. 2000
3. M. J. Chrispeels and D.F. Sadava (eds), Plants, Genes and Crop Biotechnology, 2nd Edition, Jones and Barlett Press, 2003
4. J.H. Hammond, P. Mcgarvey, and V. Yusibov (eds), Plant Biotechnology, Springer Verlag, Heidelberg. 2000
5. H.K. Das (ed), Text Book of Biotechnology, Wiley India Pvt Ltd. New Delhi, 2004
6. U. Chakraborty, Bishwanath Chakraborty, 2005. Stress biology, Vidhyasekaran, P. 2007. Narosa Publishing House
7. Handbook of molecular technologies in crop disease management, Haworth Food & Agricultural Products Press, New York. 462 p
8. Taiz and Zeiger, Plant Physiology, 3rd Edition, Panima Publishing Corporation, New Delhi, 2003.
9. Gatehouse, A. M .R., Hilder, V. A. and Boulter, D., Plant Genetic manipulation for crop protection In: Biotechnology in Agriculture Series (Eds.) Vol. 7 CAB International, Wallingford, UK. 266p. 1992
10. Panda N. and G.S.Khush, Host plant resistance to insects. CAB International, Walling Ford. 431p, 1995
11. Persely, G. J. (Ed.), Biotechnology for integrated pest management. CAB International, Wallingford, UK. 475p, 1996.
12. Slater, A., Scott, N. and Fowler, M., Plant biotechnology -The genetic manipulations of plants. Oxford University press. 346p. 2003.
13. Vidhyasekaran, P., Fungal pathogenesis in plants and crops: Molecular biology and host defense mechanisms, Marcel Dekkar Inc., New York. 624p, 1997
14. Vidhyasekaran, P., Bacterial Disease Resistance in Plants: Molecular Biology and Biotechnological Applications, Haworth Food & Agricultural Products Press, New York. 452p, 2005.
15. Zuckerman B.M. and Rohde, R. A. (Eds.), Plant parasitic Nematodes, Vol. III, Academic press, London 508p. 1981.
16. Pessaraki, M., Handbook of Plant and Crop stress, 2nd Edition, Marcel Dekker Inc. New York 1999
17. K.V. Madhava Rao, A.S. Raghavendra and K. Janardhan Reddy, Physiology and Molecular Biology of Stress Tolerance in Plants. Springer, Netherlands. 2006
18. Satoh, K. and Murata, N., Stress responses of photosynthetic organisms, Elsevier, Amsterdam. 1998

## **MSBT(EBT)-305 : Environmental Biotechnology - II**

### **Environmental Microbiology**

**1. Introduction to Environmental Microbiology-** An historical perspective and microbial ecology.

**2. Microorganisms in the Environment** - Viruses-discovery, structure, classification, infective nature and replication. Bacterial-size, shape, structure, plasmid-chromosome relationship, metabolism. Fungi, Protozoa and Algae -taxonomic diversity Size, shape, structure and types of metabolism.

**3. Microbes in the Terrestrial Environment** – General characteristics of porous media, Distribution of microbes in different soil zones and their metabolic states, role of microbes in surface soil formation, nutrients cycling, Soil pathogens and diseases in plant and human.

**4. Aeromicrobiology** - Important airborne pathogen, Aeromicrobiological Pathway, Mathematicl modelling, Sampling, Extramural aeromicrobiology—Agriculture, wasterediposal, Germ Warefare

**5. Water Microbiology** – Microbial habitat- planctons, benthic habitat, microbial mats, biofilms, microbial pathogens, Giant marine bacteria, Indicator organisms and MPN.

**6. Microbial Transport** – Microbial filtration , adhesion, cellular appendages and sedimentation, surfactants, gene transfer and nosocomial infection.

**7. Environmental Sample Collection and Processing** – Sample collection strategies and methods for air, water and soil .Culture characterisation methods by physical, immunological and nucleic acid based.

**8. Eco-friendly Microbes and their utilisation** – Probiotics,

## Biological Control of Environment

**1. Role of Biotechnology in Environment control** - What is Environmental Biotechnology? Genetic engineering approaches, Current Status of Biotechnology in Environment Protection.

**2. Bioremediation** - Overview and applications, Bioindicators, Biosensors, Phytoremediation, Phycoremediation and Mycoremediation, technologies, Advantages and disadvantages of bioremediation ,

**3. Bioremediation of Waste Water** - Importance of waste water, Biological Processes for Industrial Effluent Treatment, Aerobic Biological Treatment, Anaerobic Biological Treatment, Periodic Biological Reactors, Membrane Bioreactors, Use of Immobilized Enzymes and Microbial Cells, Use of aquatic plants, Use of soil biofilters.

**4. Bioremediation for Hazardous Waste Management** –Xenobiotic Compounds, Recalcitrance, , Hazardous Wastes, Bioaugmentation, Biosorption of Heavy metals, Biodegradation of Xenobiotics, Biological Detoxification of oil spills, Bio applications to Hazardous Waste Management, Human health and xenobiotics,

**5. Biomining.** Pyro and hydrometallurgy, Bioleaching, biooxidation, types and mechanism, Microbes in biomining, Phytomining

**6. Bioremediation for Air Pollution Abatement and Odour Control** - Deodorization Process, Applications.

**7. Biofertilisers** - Groups of biofertilisers, Microbial inoculants of nitrogen fixation, Vermicompost and Phosphocompost, Methods of production technologies

**8. Biopesticides-** Insect resistance, herbicide resistance, Resistance against Bacteria viruses and fungi,

**9. Bioenergy** - Energy conservation, energy development, alternative energy sources to reduce the impact of environmental pollution, Types and generations of bioenergy, Different production methods of bioenergy, Solar power - Solar cell & Solar heating

**10. Separation technology applicable in Environmental Biotechnology** - Types of separation technology.MBST and their cost effective application. . Physico-chemical properties of membrane. Different membrane modules and their applications. in Biotechnology and Food industries

### 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

## **PRACTICALS**

### **MSBT- 306 : LAB ON BIOPROCESS ENGINEERING**

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
5. Studying the kinetics of enzymatic reaction by microorganisms.
6. Production and purification of various enzymes from microbes.
7. Comparative studies of Ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.

### **MSBT-307 : LAB ON BIOINFORMATICS**

1. Retrieval of sequences using ENTREZ
2. Sequence analysis using BLAT, Align, Lalign
3. Multiple sequence alignment and Phylogenetic analyzing using Clustal, ClustalW
4. Studying 3D structure using RASMOL
5. Homology Modeling using Swiss PDB – Hb, Protease
6. Calculation of Phi and Psi angle - Hb, Protease
7. Docking: protein-protein; protein-small molecules
8. Potential energy calculation of regular structures
9. To mutate protein and energy minimization using Swiss PDB viewer
10. Gene prediction – Gene D'cefer
11. Adhesion protein prediction – Sea path
12. Comparative proteomics and genomics – Proteome calculator
13. Protein annotation - PLHost

### **MSBT- 308 : LAB ON FOOD TECHNOLOGY**

1. Determination of thermal process time, osmotic dehydration of food. Preparation of intermediate moisture food, clarified juice, candy and microwaved (cooked) foods. Canning of fruits and vegetables.
2. Microbial examination of natural food products, identification of food pathogen in water, milk, cereals, pulses, oilseeds, meat and poultry. Microbial production of alcohol (cereal based), acetic acid and lactic acid.
3. Determinations of proteins, starches, sugars, amino acids, crude fibre, total minerals, crude fat and water in foods. Determination of minerals-calcium, phosphorus, iron, Estimation of vitamins-ascorbic acid, carotene, thiamine. Browning reaction in food, Analysis of lipids-saponification value, acid value and iodine value, Determination of tannins, chemical residues and aflatoxins, estimation of preservative and antioxidants.
4. Techniques of quality assessment of fruits, vegetable, cereals, dairy products, meat, poultry, milk and other processed products.

### **MSBT(PBT)-309 : Pharmaceutical Biotechnology Lab**

1. SDS PAGE principles & theory of protein electrophoresis
2. Preparation of buffers & solutions for SDS PAGE
3. Assembly of gel apparatus & preparation of protein samples
4. Loading of samples & running of gel & de-assembling the apparatus
5. Staining & de-staining of gel followed by interpretation of results.

### **MSBT(MBT)-309 : Microbial Biotechnology Lab**

1. Identification of a microorganism by biochemical tests
2. Ampicilin selection of auxotrophs
3. Mutagenesis in bacteria by Ames test
4. NTG mutagenesis in *E.coli*
5. Ethanoic acid production
6. Production of Sauerkraut
7. Isolation of Nitrogen fixing and Sulphur reducing bacteria from soil
8. Bioremediation using GFP cloned *E.coli*
9. Isolation of bacteriophage from sewage and determination of phage titer
10. Effect of temperature & pH on microbial growth, techniques for cultivation of anaerobic bacteria.

### **MSBT(ABT)-309 : Agricultural Biotechnology Lab**

1. Isolation of pure cultures of microorganisms from soil and water
2. Plant DNA extraction, digestion of DNA with restriction enzymes, agarose gel electrophoresis.
3. Polymerase chain reaction to amplify a plant gene.
4. Homogenization of leaves, sub-cellular fractionation by differential centrifugation, chloroplast purification and estimation
5. Preparation of Murashige and Skoog medium, stocks of macronutrients, micronutrients, vitamins and hormones, autoclaving, filter sterilization of hormones and antibiotics.
6. Surface-sterilization of seeds, plantlet production and acclimatization of tissue culture plants in field.
7. Callus induction, regeneration of shoots, root induction, role of hormones in morphogenesis.
8. Chromosome analysis from *in vitro* culture
9. Protoplast isolation, viability test and culture
10. Methods to measure various physiological processes (photosynthesis, transpiration, gas exchange, Chlorophyll estimation, cell membrane stability) in plants
11. Secondary metabolite extraction and purification from microbes/plants
12. Estimation of Total Phenol, Total Flavonoid and screening of Phytocomponents from plants/ herbal products

## **MSBT(EBT)-309 : Environmental Biotechnology Lab**

1. Microbial community isolation from soil and water
2. Identification of a microorganism by biochemical tests
3. Detection of heavy metals from industrial effluent
4. Assay of Nitrate, Sulphate and Phosphate in soil
5. Laboratory Scale preparation of a biofertilizer
6. Isolation of an antibiotic producer from soil.
7. Acute toxicity testing of xenobiotics in mice and fish
8. Estimation of protein and haematological parameters from mice after exposure of pollutants
9. Characterisation of a compound as mutagen in bacteria by Ames test
10. Effect of temperature & pH on microbial growth, techniques for cultivation of anaerobic bacteria.

## **MSBT-310 : Project Presentation based on Elective Paper**

Formulation of a Research proposal by visiting Industry / Institute / University and by presentation in a Seminar.

Suggestions :

Lectures: preparation, objective/s, concepts, contents, sequence, formal proof, interrelationships, logic, conclusions, time management, using audiovisual aids.

Giving a talk: body language: extempore and prepared talks.

Preparing for interviews, CV/biodata.

Vocabulary: word power, pronunciations, guessing the meaning of words from the context and body language

Avoiding repetitious statements, double positives, double negatives, circular arguments.

Dealing with questions: avoiding circumvention and circular arguments; answering after breaking down long questions into parts.

MS power point-based presentations.

## **FOURTH SEMESTER**

### **MSBT - 401 : BIO-ENTREPRENEURSHIP**

**1. Accounting and Finance** - Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial institution and Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping; Estimation of income, expenditure, profit, income tax etc.

**2. Marketing** - Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising; Services Marketing.

**3. Negotiations/Strategy** - With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/Avoiding/Managing; Broader vision–Global thinking.

**4. Information Technology** - How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.

**5. Human Resource Development (HRD)** - Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.

**6. Fundamentals of Entrepreneurship** - Support mechanism for entrepreneurship in India.

**7. Role of knowledge centre and R&D** - Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.

**8. Case Study** - Candidates should be made to start a 'mock paper company', systematically following all the procedures. The market analysis developed by them will be used to choose the product or services. A product or service is created in paper and positioned in the market. As a product or services available only in paper to be sold in the market through the existing links. At this juncture, the pricing of the product or the service needs to be finalized, linking the distribution system until the product or services reaches the end consumer. Candidates who have developed such product or service could present the same as a project work to the Panel of Experts, including representatives from industry sector. If the presented product or service is found to have real potential, the candidates would be exposed to the next level of actual implementation of the project. [Go to any venture capital website (like sequoiacap.com) and prepare a proposal for funding from venture capital]

## **MSBT- 402 : IPR AND BIOSAFETY**

### **IPR**

**1. Introduction to Intellectual Property** - Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies.

**2. Agreements and Treaties** - History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

**3. Basics of Patents and Concept of Prior Art** - Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)

**4. Patent filing procedures** - National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – disclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies

**5. Intellectual property rights and Social-legal Aspects of Biotechnology** - A commercial view of Biotechnology and its application in Industry, Patenting Biological material, Opposition to patents in Biotechnology, Special issues (Public opinions against the technologies), Legal Issues (legal guide lines of different countries), Ethical issues (against the technologies).

## **BIO SAFETY**

**1. Introduction** - Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards;

**2. Biosafety Levels** - Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

**3. Biosafety guidelines** - in Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

**4. Regulating Recombinant DNA Technology** - Approaching the biohazard problem, Environmental and Regulatory Aspects of Using Genetically Modified plants, Relevance of multiple Environment Testing, Environmental and Regulatory aspects of using GMMS,

**5. Biosafety protocol** - International protocols, International Activities in Biosafety Capacity Building, Biosafety Regulations in India, Biological Weapons, Biosafety and Ethical Issues.

### **Texts/References:**

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007

2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

### **Important Links:**

<http://www.w3.org/IPR/>

<http://www.wipo.int/portal/index.html.en>

[http://www.ipr.co.uk/IP\\_conventions/patent\\_cooperation\\_treaty.html](http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html)

[www.patentoffice.nic.in](http://www.patentoffice.nic.in)

[www.iprlawindia.org/](http://www.iprlawindia.org/) - 31k - Cached - Similar page

<http://www.cbd.int/biosafety/background.shtml>

<http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm>

## **MSBT-403: Comprehensive Viva-voce**

## **MSBT-404 : INDUSTRY / Institute Visit & Formulation of a Research Proposal / Seminar**

## **MSBT-405: Dissertation (Independent Project Work based on Elective Paper)**

Each student will undertake an experimental project under supervision of one of the teachers during Semester 4 and submit TWO copies of the dissertation which will include: a) Review of the relevant literature, b) Objectives of the study, c) Materials and Methods, d) Results/Observations (supported by figures/tables etc as required), e) Discussion of the Results/Observations, f) Summary and g) References.