M.Sc. BIOTECHNOLOGY SCHEME for 2016-17

CORE COURSES

Name of the Course	Course Code	No of Credits	Course Level
SEMESTER I			
Fundamentals of Microbiology	GBT 101	3	100
Concepts in Biochemistry	GBT 102	3	100
Principles of Genetics & Molecular Biology	GBT 103	3	100
Bioinstrumentation	GBT 104	2	100
Biostatistics	GBT 105	2	100
Lab in Microbiology	GBL 101	2	100
Lab in Biochemistry	GBL 102	2	100
Lab in Molecular Genetics	GBL 103	2	100
SEMESTER II			
Introductory Immunology	GBT 111	3	100
Lab in Immunology	GBL 111	2	100
Seminar Presentations	GBM 111	1	100

Name of the Course	Course Code	No of Credits	Course Level
SEMESTER III			
Bioprocess & Industrial Biotechnology	GBT 221	3	200
Recombinant DNA Technology	GBT 222	3	200
Lab in Fermentation technology	GBL 221	2	200
Lab in Recombinant DNA Technology	GBL 222	2	200
Field Trips & Report	GBM 221	1	200
SEMESTER IV			

Advances in Plant Biotechnology	GBT 331	3	300
Seminar Presentations	GBM 231	1	200

OPTIONAL COURSES

Name of the Course	**Course Code**	**No of Credits**	**Course Level**
SEMESTER I			
Scientific writing	GBT 106	1	100
SEMESTER II			
Bioinformatics	GBT 112	2	100
Plant Tissue Culture Technology	GBT 212	2	200
Enzymology	GBT 224	3	200
Lab in Bioinformatics	GBL 112	2	100
Lab in Plant tissue culture	GBL 113	1	100
Lab in Enzyme Characterization	GBL 223	2	200
Environmental Biotechnology	GBT 213	2	200
Food Biotechnology	GBT 214	2	200

Name of the Course	**Course Code**	**No of Credits**	**Course Level**
SEMESTER III			
Animal Cell Culture	GBT 223	2	200
Cell & Developmental Biology	GBT 211	3	200
Molecular Immunology	GBT 225	3	200
Lab in Animal Cell Culture	GBL 121	2	100
Nanobiotechnology	GBT 121	2	100
SEMESTER IV			

Advances in Animal Biotechnology	GBT 332	3	300
Bioentrepreneurship	GBT 131	2	100
Biosafety & IPR	GBT 231	3	200

Dissertation (compulsory)*****	GBM 331	12*	300

*** As per Ord. OA-18.3 as notified on 11 June 2014**

Syllabus - M.Sc. BIOTECHNOLOGY

SEMESTER I

GBT 101 : FUNDAMENTALS OF MICROBIOLOGY

MODULE I

- A brief history of microbiology: discovery of the microbial world, controversy over spontaneous generation, role of microorganism in causation of disease, development of pure enrichment culture methods.
- Modern /contemporary microbiology in 21st century
- An overview of the organization and cell structure of Prokaryotes and Archaea:

  i) cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups.

MODULE II

- Microbial nutrition: i) autotrophic & heterotrophic modes, ii) defining culture media to support growth, iii)selective and differential culture media.

- Bacterial growth kinetics: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth iv) chemostat & turbidostat.

- Microbial taxonomy: i) nomenclature ii) polyphasic identification, traditional & molecular, iii) Bergey's manual.

MODULE III

i) Structure & classification.

- Algae
- Fungi
- Cyanobacteria
- Bacteria
- Viruses
- Viroids & prions

ii) Specialized microorganisms:

- Marine microbes
- Extremophiles : barophiles, psychrophiles, thermophiles, halophiles.acidophiles
- Anaerobes

REFERENCES:

1. Brock's Biology of microorganisms. (2007). Madigan, M., Martinko & Parker, J.Pearson Prentice Hall
2. Microbiology: Fundamentals and Applications. (1989). Atlas, R.M.
3. Microbiology (1996). M J Pelezar, Chan E C S and Krige
4. Industrial Microbiology. (1987). G Reed, Prescott & Dunn, CBS Publishers.
5. General Microbiology. (1987). Stanier, R.Y., Ingraham, Wheelis and Painter
6. Aquatic Microbiology:An ecological approach. (1993). Ford T E.Blackwell Scientific Publication. Aquatic Microbiology
7. Aquatic Microbiology (1980) Rheinhemer,G, John Wiley and sons. New York.
8. Microbial ecology of the ocean (2000) Wiley,New York.
9. Marine and Estuarine Microbiology Laboratory Manual. (1975). Colwell, R. et al.
10. Microbiology Methods. (1975). Collins, C.H. and Lyne, P.M.
11. Source book of Experiment for the teaching of Microbiology. (1982). Primrose, S.B. and Wardlaw, A.C.
12. Laboratory Methods in Microbiology. (1973). Harrigan, W.F. & McCance, M.E.

GBT 102 : CONCEPTS IN BIOCHEMISTRY

MODULE I

Biochemistry: the molecular logic of life.

Biochemical evolution: principles and mechanisms.

Buffering in biological systems.

Enzymes: catalytic power and specificity

Amino acids; structure and functional group properties.

Peptides and covalent structure of proteins

Levels of structural organization, sequencing, 3-D structure and

functional diversity of proteins, the concept of the proteome.

- Elucidation of primary and higher order structures
- Structure-function relationships in model proteins

MODULE II

Carbohydrates - structure and biological role.

Basic concepts and design of metabolism - glycolysis, gluconeogenesis, the pentose phosphate pathway; the TCA cycle.

Structure and diversity of biological membranes; mechanisms of membrane transport.

Bioenergetics – basic principles. Thermodynamic quantities and laws, equilibria and concept of free energy, ATP as the main carrier of free energy in biochemical systems.

MODULE III

Lipids – Structure and biological role

Fatty acid synthesis, β-oxidation.

Overview of amino acid biosynthesis.

General principles of intermediary metabolism and regulation of pathways.

De novo synthesis and salvage pathways in nucleotide metabolism.

Electron transport

Oxidative phosphorylation.

Photosynthesis.

Vitamins and hormones: chemistry and physiological role.

REFERENCES :

1. Principles of Biochemistry (2008). Lehninger A.L. (ed.)
2. Biochemistry (2002). Stryer, L.
3. Principles of Biochemistry (1995). Zubay, G.L., Parson, W.W. & Vance, D.E.
4. Harper's Biochemistry (1990). Murray, R.K. et al
5. Biochemistry (2004). Voet, D. & Voet J.G.
6. Biochemistry and Molecular Biology (2005). Elliott, W.H. & Elliott, D.C.
7. Fundamentals of Biochemistry (1999). Voet, D., Voet, J.G & Pratt,C.W.
8. Introduction to Protein Structure (1999). Branden C. & Tooze J.

GBT 103 : PRINCIPLES OF GENETICS & MOLECULAR BIOLOGY

MODULE I

DNA structure & topology; organelle genomes.

DNA reassociation kinetics, DNA repetitive sequence

DNA packaging in viruses, bacteria & eukaryotes.

Epigenetics

Mutation: spontaneous & induced mutation; types of mutagens

DNA repair in prokaryotes & eukaryotes

Transposon, retroposons

MODULE II

Transcription

Prokaryotic & eukaryotic promoters, mRNA, rRNA, tRNA, RNA polymerases

Transcription initiation & termination, transcription factors, RNA processing

Ribosomes

Initiation, elongation & termination

Translation factors

Genetic code: genetic code is triplet, codon – anticodon

Wobble hypothesis

Characteristics of genetic code

Operon: lac, Trp

Genetic diseases

MODULE III

Gene transfer in bacteria: transformation, conjugation, transduction

Population genetics: Hardy Weinberg law

Biology of λ-bacteriophage

Recombination

DNA replication in prokaryotes & eukaryotes: DNA polymerases (prokaryotes & eukaryotes), replicon (prokaryotes & eukaryotes), model for DNA replication (prokaryotes & eukaryotes), termination, D-loop & rolling circle model for DNA replication

REFERENCES :

1. Genes X (2010). Lewin, B.
2. Essential Genes (2006) Lewin.
3. Essential Genetics: A genome perspective. Hartl and Jones (4th Edition)
4. Principle of Genetics. Gardner, E.J., Simmons, M.J. & Snustad, D.P. (8th Edition)
5. Genetics (2002). Strickberger, M.

6. Molecular Biology of the Cell (2002) Alberts. e*t al.*
7. Molecular Biology of the Gene (2008) Watson *et al.*
8. Cell and Molecular Genetics (1987) Schlesf, R.
9. Microbial Genetics (2006). S.Maloy, J.Cronan Jr and Friefelder, D
10. Concept of Genetics (2002). Klug, W.S. & Michael, R & Cummins, M.R.
11. igenetics: A molecular approach (2005). Russel, P.J.

GBT 104 : BIOINSTRUMENTATION

MODULE I

Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy, XRD, HPLC and FPLC.

MODULE II

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.

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). Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application.

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, 3rd Edition, Springer Verlag, 1994.
5. Selected readings from Methods in Enzymology, Academic Press.

GBT 105 : BIOSTATISTICS

MODULE I

Scope of Biostatistics

Brief description and tabulation of data and its graphical representation, frequency distributions

Measures of Central Tendency and dispersion: mean, median, mode, range, standard deviation, variance, coefficient of variation, skewness, kurtosis

Displaying data: Histograms, stem and leaf plots, box plots

Probability analysis: axiomatic definition, axioms of probability : addition theorem, multiplication rule, conditional probability and applications in biology.

MODULE II

Counting and probability, Bernoulli trials, Binomial distribution and its applications, Poisson distribution, Normal distribution, z, t and chi square tests, levels of significance

Testing of hypotheses: null and alternative hypothesis, Type I and Type II errors

Simple linear regression and correlation

Analysis of variance

REFERENCES :

1. Introduction to Biostatistics (1973). Sokal,R. et al.
2. Statistical methods: George, W.S. & Harward,W.G.
3. Statistical method in Biology. University Press Ltd.
4. Biostatistics. (1984). Zar, J.

GBL 101 : LAB IN MICROBIOLOGY

- Sterilization and disinfection.
- Preparation of solid & liquid media:

- Differential and Selective media
- Enumeration: serial dilution methods, plating.
- Isolation and maintenance of organisms:
- Streaking, slants and stabs cultures, storage of microorganisms.
- Isolation of bacteria from terrestrial/marine samples.
- Study of morphology and cultural characteristics
- Gram staining.
- Motility
- Cell inclusion studies: metachromatic granules
- Spore staining
- Biochemical characterization and identification of bacteria
- Cultivation of fungi: Slide,chunk and coverslip techniques
- Culture of anaerobes.

REFERENCES:

1.Brock's Biology of microorganisms. (2006). Madigan, M., Martinko & Parker, J.

2.General Microbiology. (1987). Stanier, R.Y., Ingraham, Wheelis and Painter

3.Marie and Estuarine Microbiology Laboratory Manual. (1975). Colwell, R. et al.

4.Microbiology Methods. (1975). Collins, C.H. and Lyne, P.M.

5.Laboratory Methods in Microbiology. (1973). Harrigan, W.F. & McCance, M.E.

6.Source book of Experiment for the teaching of Microbiology. (1982). Primrose, .B. and Wardlaw, A.C.

GBL 102 : LAB IN BIOCHEMISTRY

- Principles of colorimetry
- Spectral characteristics of coloured solutions.
- Estimation of proteins by the Biuret method
- Estimation of proteins by the Lowry's method
- UV absorption of proteins

- Estimation of sugars.
- Titration curves of amino acids
- Paper chromatography.

REFERENCES :

1. Modern experimental Biochemistry (2003). Boyer, R.
2. Principles and Techniques of Biochemistry and MolecularBiology (2005). Wilson, K. & Walker, J.
3. An Introduction to Practical Biochemistry.(2005). Plummer,D.T.
4. Laboratory Manual of Biochemistry.(1998). Jayaraman, J.

GBL 103 : LAB IN MOLECULAR GENETICS

- DNA isolation a) bacterial cell , b) bacteriophage.
- RNA isolation from bacterial cell.
- UV survival curve for *E.coli.*
- Chemical mutagenesis & isolation of auxotrophs by replica plating.
- Transformation.
- Conjugation & gene mapping by Transduction.
- Transposon mutagenesis.
- Transduction.

REFERENCES :

1. Experiments in molecular Genetics (1972) Miller J.H.
2. Laboratory manual in Molecular Genetics (1979). Jayaraman, K & Jayaraman, R.

GBT 106 : SCIENTIFIC WRITING

MODULE I

Technical Writing Skills

Types of reports; Layout of a formal report; Scientific writing skills:

Importance of communicating Science; Problems while writing a

scientific document; Plagiarism; Scientific Publication Writing:

Elements of a Scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts

Computing Skills for Scientific Research

Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in Scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness

REFERENCES :

1. Mohan Krishna and N.P. Singh, Speaking English effectively, Macmillan, 2003

SEMESTER II

GBT 111 : INTRODUCTORY IMMUNOLOGY

MODULE I

- Introduction – History and scope of immunology
- Phylogeny of immune system
- Innate and acquired immunity:- factors, features, processes
- Clonal nature of immune response
- Organization and structure of lymphoid organs
- Cells of the immune system: Hematopoiesis and differentiation, lymphocyte trafficking, B lymphocytes, T lymphocytes, macrophages, dendritic cells, natural killer and lymphokine active killer cells, eosinophils and mast cells, lymphocyte subpopulations and CD markers.
- Nature and biology of antigens and superantigens: haptens, adjuvants, carriers, epitopes, T dependant and T independent antigens.

MODULE II

- Theories of antibody formation.
- Humoral immunity: cells, antibody formation, primary and secondary response.
- Immunoglobulins – structure, distribution and function.
- Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics.
- Immuno-diagnostics

MODULE III

- Major histocompatibility complex.
- Complement system: mode of activation, classical and alternate pathway.
- Cell mediated immune responses: cell activation, cell-cell interaction and cytokines.
- Cell-mediated cytoxicity: Mechanism of T cell and NK cell mediated lysis, antibody-dependant cell-mediated cytoxicity, and macrophage-mediated cytoxicity.
- Hypersensitivity: An introduction to the different types.
- Hybridoma technology and monoclonal antibodies.
- Introduction to autoimmune diseases.

REFERENCES :

Essential Immunology (2005) Roitt I.M. and Delves P.J.

Immunology – Roitt I, Bostoff J. & Male D.

Immunology (2006) Luttmann M, Bratke K, Kupper M & Myrtek D.

Immunology (2007) Goldsby R.A., Kindt T.J., Osbrne B.A. and Kuby J.

GBL 111 : LAB IN IMMUNOLOGY

- Blood grouping
- Single and double immunodiffusion
- Assessment of antigen similarity using Ouchterlony double diffusion test.
- Determination of antibody titre using double diffusion
- Estimation of Ag/Ab using radial immunodiffusion
- Quantitative precipitin assay
- DOT ELISA test
- Immunoelectrophoresis
- Antibody – HRP conjugation
- Latex Agglutination test
- Counter current immunoelectrophoresis
- Immunoblotting
- Rocket immunoelectrophoresis

REFERENCES:

1. Practical Immunology (2003). 4th edition Frank, C. Hay & O.M.R. Westwood.

GBT 112 : BIOINFORMATICS

MODULE I

- Databases - Definition, data mining methods and analysis tools
- Biological Database- Primary, secondary and composite

- Various types of databases

  Nucleic acid sequence database

  Protein sequence database.

  Protein structure database

  Taxonomic database.

  Genomic database.

  Protein families, domains and functional sites

  Enzyme/metabolic pathway database (EMP and Brenda),

  Regulatory pathway (KEGG)

- Tools for similarity searches and sequence alignments.
- Alignment of pair sequences- methods and scoring alignments (Global Alignments
- Needleman Wunsch Algorithm and Local Alignments - Smith Waterman Algorithm)
- Scoring matrices: PAM and BLOSSUM
- Alignment of multiple sequence alignment and phylogenetic analysis- method of evaluation of multiple alignment. Phylogenetic analysis and tree evaluation methods.
- Profiles and Hidden Markow model. Artificial neural networks, support vector machines (supervised machine learning)

MODULE II

- Gene identification and prediction: pattern recognition and gene prediction methods
- Protein structure prediction- primary and secondary structure analysis and prediction, motifs, profiles, patterns and fingerprint search, *comparative protein model* for protein prediction, methods of 2-D structure prediction, protein function prediction from a DNA sequence.
- Pharmacogenetics- high throughput screening for drug discovery- identification of drug targets; Drug development.
- Functional Genomics-global gene expression analysis; Micro-array; comparative transcriptomics; Differential gene expression
- Proteomics: definition; identification and analysis of protein by 2D analysis; techniques for studying proteome.

REFERENCES :

1. Bioinformatics-sequence, structure and databanks, (2000) D. Higgins and W. Taylor A practical approach.

2. Bioinformatics computing (2003). B. Bergeman.
3. Bioinformatics databases and algorithms (2007) N. Gautham.
4. Basic Bioinformatics (2005) S. Ignacimuthus.
5. Bioinformatics:concepts skills and applications (2004). S.C. Rastogi, N. Mentiratta and P. Rastogi.
6. Bioinformatics: A modern approach, (2005) V.R. Srinivas.
7. Essential Bioinformatics (2006). J. Xiong).
8. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant.

GBT 212 : PLANT TISSUE CULTURE TECHNOLOGY

MODULE I

- Laboratory requirement and general techniques.
- Tissue culture media.
- Cellular totipotency, somaclonal variation, micropropagation techniques
- Somatic embryogenesis.
- Haploid production.
- Protoplast isolation and culture.
- Production of pathogen-free plants.

MODULE II

- Axenic culture of seaweed and tissue culture.
- Germplasm storage.
- Embryo culture
- Ovule and seed culture.

REFERENCES :

1. Plant Tissue culture: Basic and applied (2006) T. Jha and B. Ghosh.
2. Plant Biotechnology: Methods in tissue culture and gene transfer (2006). R. Keshavachandra and K.V. Peter.
3. Plant, cell, tissue and organ culture (2005) Gamborg and Phillips.
4. Plant cell and Tissue culture.(2005). I Vasil and T. Thorpe.
5. Plant tissue culture: Theory and practice- revised editions. Bhojwani and M. Rajdan
6. Plant cell & tissue culture. (1994). Vasil, I.K. & Thorpe, T.A.
7. Plant tissue culture: Applications and limits. (1990). Bhojwani, S.S.
8. Plant propagation by tissue culture (1984) George, E.F. & Sherrington, P.D.

GBT 224 : ENZYMOLOGY

Module I

Classification and nomenclature of enzymes.
Effect of pH, temperature, ions, etc. on enzyme activity.
Enzyme extraction and assay.
Enzyme purification: principles and techniques of salting in and out, molecular sieving, ion exchange and affinity chromatography, gel electrophoresis, isoelectric focusing, 2-D electrophoresis.

Module II

Isozymes ; *in situ* localization of enzymes in gels.
Catalytic mechanisms: mechanism of action of lysozyme, chymotrypsin etc.
Cofactors and Coenzymes.
Allosteric enzymes.
Reaction kinetics, order and molecularity; steady state kinetics; analysis of kinetic data; enzyme inhibition.
Multisubstrate reactions.
Enzyme activation.
Biological regulation of enzyme activity.

Module III

Enzyme modification.
Clinical and industrial applications of enzymes; enzyme immobilization.
Ribozymes, catalytic antibodies and their applications.
Enzyme fusion.
Biosensors.

REFERENCES:

1. Enzymes. (1979). Dixon M. & Webb E.C.
2. Methods in Enzymology (relevant volumes of the series)
3. Fundamentals of Biochemistry. (1999). Voet, D., Voet, J.G & Pratt,C.W.
4. Genes VII. (2000). Lewin, B.
5. Biological Chemistry. (1986). Mahler, H.R. and Cordes E.
6. Bioseparations: Principles & Techniques (2005). Sivasankar B.
7. Enzymes- a practical introduction to structure mechanism and data analysis (2000). Copeland, R.A.
8. Enzymes: Biochemistry, Biotechnology & clinical chemistry (2004). Palmer, T.

GBL 112 : LAB IN BIOINFORMATICS

- Search engines for bibliographic search
- Construction of plasmid map.
- Database search engines (Entrez/SRS) and submission of DNA/protein sequence.
- Exploring protein structure using RASMOL/Discovery studio/view
- Designing PCR primers and probes.
- Fundamentals in C-programming and construction of small programs in Bioinformatics .
- Reconstruction of phylogenetic tree using molecular data (Distance-based method or Neighbor-joining).
- Tools for Genomic Data Mining
- Basic of Genome Annotation
- Special tools for searching genomic data
- Prediction of ORFs and Genes
- Prediction of Signal sequences (Promoters, splice sites, UTRs etc. sequence
- analysis tools (Bioedit/MEGA)
- Browsing & viewing genome data
- Ensembl@EBI
- MapViewer@NCBI
- Drug designing.
- Immunoinformatics

- ---Prediction of B and T cell epitopes for vaccine drug design
- Comparative and structural genomics.
- Proteomics (Expasy) and Interprotein Scan- pattern/motiof detection in proteins
- Protein-Protein interaction

REFERENCES :

1. Practical Bioinformatics (2006) J. Bajnieci (Ed)
2. Bioinformatics (1995). A Practical guide to analysis of genes and protein.

GBL 113 : LAB IN PLANT TISSUE CULTURE

- Sterilization of explants and callus induction.
- Regeneration of plantlet from callus.
- Single cell suspension and protoplast isolation.
- Axenic culture & tissue culture of seaweeds.
- Somatic embryogenesis.
- *Agrobacterium* gene transfer.

REFERENCES:

1. Plant Biotechnology: methods in tissue culture and gene transfer (2006). R. Keshavachandra and K.V. Peter.
2. Plant tissue culture: theory and practice (revised editions). Bhojwani and M. Rajdan

GBL 223 : LAB IN ENZYME CHARACTERIZATION

1. Enzyme isolation – preparation of cell-free lysates
2. Ammonium sulphate precipitation
3. Dialysis
4. Gel filtration
5. Ion exchange chromatography
6. Affinity chromatography
7. Enzyme kinetic parameters
8. Assessing protein purity by native polyacrylamide gel electrophoresis
9. Molecular weight determination by SDS-PAGE

REFERENCES:

1. Modern Experimental Biochemistry (2003). Boyer, R
2. Fundamentals of Biochemistry. (1999). Voet, D., Voet, J.G & Pratt,C.W.
3. Bioseparations: Principles & Techniques (2005). Sivasankar B.

GBT 213 : ENVIRONMENTAL BIOTECHNOLOGY

MODULE I

Enviromental pollution; Source of pollution.

Control, remediation and management
Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment.

MODULE II

Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries, Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Solid waste management, Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.

REFERENCES:

1. MetCalfe and Eddy Inc., Wastewater Engineering: Treatment, Disposal and Reuse", 4 th Edition, McGraw HillBook Co., 2003
2. Mackenzie L. Davis and David A. Cornwell, Introduction to Environmental Engineering, 4 th Edition, McGraw Hill Book Co., 2006.
3. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, Environmental Microbiology: A Laboratory Manual, 2 nd Edition, Academic Press, 2004.
4. B.C.Bhattacharyya and R.Banerjee, Environmental Biotechnology, Oxford University Press
5. I.S.Thakur, Environmental Biotechnology: Basic Concepts and Applications, I.K.International.

GBT 214 : FOOD BIOTECHNOLOGY

MODULE I

Industrial and Food Biotechnology; Introduction; History; Importance; Applications of biotechnology in food processing; Significant advances; Recent developments; Risk factors; Safety regulations etc. Bioprocessing – Industrial use of micro organisms; Microbes exploited commercially- *Lactobacillus, Acetobactor, Bifidobacterium, Lactococcus, Streptococcus*.

MODULE II

Fermentation-process, media and systems; Product development; Dairy fermentation and fermented products. Microbial enzymes in food processing; Food and beverage fermentation-non alcoholic beverages; Food additives and supplements – probiotics, health care products, vitamins and antibiotics.

REFERENCES :

1. Gautam, N. C., Food Biotechnology in Comprehensive Biotechnology, Vol. 6., Shree Publishers, New Delhi, 2007.
2. Gutierrez – Lopez, G. F. *et. al*., Food Science and Food Biotechnology. CRC Publishers, Washington, 2003.
3. Maheshwari, D. K. et. al., Biotechnological applications of microorganisms, IK . International, New Delhi, 2006.
4. Stanbury, P. F. *et. al.*, Principles of Fermentation Technology, 2nd Edition, Elsevier, UK, 1995.
5. Waites, M. J. *et. al*., Industrial Biotechnology: An Introduction, Blackwell publishing, UK, 2007.

Semester III

GBT 221: Bioprocess and industrial Biotechnology

Module I

Basic Principles of Biochemical Engineering and Fermentation Processes:
Isolation, screening, and preservation of industrially important microbes
Bioreactor designs
Types of fermenters
Concepts of basic modes of fermentation: batch, fed-batch and continuous
Scale up fermentation processes
Media formulation
Air and media sterilization.
Aeration & agitation in bioprocess.
Measurement and control of bioprocess parameters.

Module II

Industrial production of chemicals :
Strain improvement for increased field & other desirable characteristics
alcohol (beer)
organic acids (citric acid)
antibiotics (Penicillin)
amino acids (lysine)
Application of microbes in food processing: manufacture of cheese and monosodium glutamate

Module III
Downstream Processing:
introduction, removal of microbal cells & solids
bioseparation, filtration, centrifugation sedimentation.
flocculation, cell disruption, liquid-liquid extraction,

Purification by chromatographic techniques
Drying, crystallization.
Storage & Packaging
Effluent treatment & disposal.
Immobilization of microbial cells & their applications
Bioprocess for the production of biomass: yeast and mushrooms
Single cell proteins

REFERENCES :

1. Encyclopedia of bioprocess technology. Vol 1-5. (1999). Flickinger, M.C. & Drew, S.W.(Ed).
2. Fermentation technology. (1994). Cassida.
3. Bioprocess engineering: Down stream processing & recovery of bioproducts, safety in biotechnology and regulations. (1990). Behrens, D. & Kramer, P.(Ed).
4. Fundamentals of biotechnology. (1987). Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (Ed.)
5. Comprehensive biotechnology. Vol 2-4. (1985). &Young, M. (Ed)
6. Chemical engineering. (1984). Coulson, J.M. & Richardson, J.F.
7. Principles of fermentation technology. (1984). Stanbury, F. & Whitaker,A.
8. Immobilized enzymes: An introduction & application in biotechnology. (1980). Trevan, M.D.
9. Topics in enzyme & fermentation technology. (1984). Wiseman, A. (Ed

GBT 222: Recombinant DNA Technology

Module I

DNA modifying enzymes and their uses in Molecular Biology a)Restriction enzymes b) DNA Polymerases I) Klenow ii) DNA polymerase I iii) T4/T7 DNA polymerase c) Reverse Transcriptase d) Terminal Transferases e) T4 Polynucleotide Kinases & Alkaline phosphatases f) DNA dependent RNA polymerases. g) DNA ligases h) Nucleases:- Bal 31, Sl nucleases, DNase I, mungbean nucleases, Ribonucleases, Exo III. Thermostable DNA polymerases used in PCR.

Module II

Cloning vectors and their applications a) Plasmids of Gram +ve & Gram –ve bacteria b) Phages – Lambda and M13 vectors c) Cosmids d) Phagemids 3. Specialized vectors & their uses a) Expression vectors for prokaryotes & Eukaryotes b) Gene fusion vectors c) Yeast vector. d) Drosophila genetic element based vectors. DNA cloning a) Sticky ends b) Blunt ends c) Homopolymeric tailing d) Use of adapters & linkers. Construction of genomic libraries (shotgun cloning) Construction of cDNA libraries. Preparation of radiolabelled/non radiolabelled DNA & RNA probes.

Module III

Screening of genomic libraries with oligoprobe & antibodies. Technique of DNA and plasmid isolation with special reference to commercial kits, Equilibrium density gradient centrifugation, DNA finger printing, Foot printing, Northern/Southern/Western blot, dot/zoo blot Chromosome jumping, Chromosome walking, DNA sequencing. Site directed mutagenesis.

REFERENCES :

1. Biotechnology. (1998). Singh, B.D.
2. Genetic engineering: principles & practice (1996). Mitra, S.
3. Principles of gene manipulations (1996) Old,R.W. & Primrose,S.B.
4. The basic principles of gene cloning (1996). Brown, T.A.
5. An introduction to Genetic engineering.(1994). Nicholl,D.S.T.
6. Recombinant DNA. (1992). Watson et al.
7. Genetic engineering fundamentals: An introduction to principles & applications. (1989). Kammermeyer,K. & Virginica,C.
8. From Genes to Clones: Introduction to Gene Technology. (1987). Winnacker, E.L.
9. Genetic engineering Vol I-VI Setlow and Halander.
10. Genetic engineering Vol I-IV (1981). Williamson, R.(Ed.).

GBL 221: LAB IN FERMENTATION TECHNOLOGY

1. Microbial production of ethanol using yeast sp.
2. Estimating ethanol concentration by Cerric Ammonium nitrate method.
3. Microbial production and estimation of organic acids: Citric acid using *Aspergillus* sp.
4. Microbial production of antibiotics.
5. Immobilization of microbial cells: use of alginate.
6. Use of fermenter with special reference to scale-up operations.
7. Batch and continuous culture.
8. Manufacture of ginger ale.
9. Mushroom cultivation.

REFERENCES:

1. Practical Fermentation Technology (2008) Brian Mcneil and Linda Harvey. Wiley

GBL 222: LAB IN RECOMBINANT DNA TECHNOLOGY

Plasmid isolation by alkaline lysis and boiling method. Ethidium bromide/CsCl density gradient centrifugation. Transformation of plasmid using competent bacterial cells. Restriction mapping. Cloning a) Restriction of plasmid and alkaline phosphatase treatment. b) Ligation of insert. c) Selection/screening for recombinant. Transfection and preparation of ssDNA. PCR. RT-PCR. Western blotting. Southern blotting. DNA sequencing.

REFERENCES :

a. Molecular cloning (1989) Maniatis,T. *et al*
b. Recombinant DNA methodology. (1985). Dillon, R.G., Nasim, A. & Nestmann. E.R.

GBM 221: FIELDTRIPS AND REPORT (2014-2015 onwards)

Contact hours: 15 × 3=45 **Credits: 01**

Designed to create and develop an inclination to entrepreneurship and an awareness of career possibilities in the field of biotechnology.

1.	Visit to distilleries
2.	Visit to an effluent treatment plant
3.	Visit to Centre for Incubation and Business Acceleration
4.	Visit to a pharmaceutical industry
5.	Exposure to Aquaculture farming
6.	Exposure to vermicomposting techniques
7.	Exposure to organic farming techniques
8.	Exposure to mushroom cultivation techniques
9.	Exposure to horticulture techniques
10.	Exposure to floriculture techniques
11.	Visit to an entrepreneur's unit

- 45 hours to be completed during Semester III .

- Out of the 11 topics mentioned above, 5 will be organized during the Semester, depending on the prevailing logistics.
  (Each field trip will be of 6h duration; 5×6=30h, plus 15h for report writing).
- Every student will be evaluated based on attendance, performances in the field, field note book entries and the consolidated field report.

GBT 223: ANIMAL CELL CULTURE

Module I

1. INTRODUCTION
Introduction to tissue culture
History and concepts of Animal cell culture
Applications and limitations
2. DESIGNING AND EQUIPPING THE TISSUE CULTURE LAB :
Laboratory design
Equipment needed and used
Glassware and plasticware - tissue culture vessels
3. ASEPTIC TECHNIQUES
4. TYPES OF TISSUE CULTURE
Primary Cultures : explant culture
Cell cultures: sources, types-adherent/suspension, kinetics of cell growth, rodent and human cell cultures, techniques for isolation , methods for cell separation.
Organ cultures – techniques for organ culture, histotypic, organotypic, organoids and 3D cultures.
Stem cell cultures.
Embryo cultures and IVF.

Module II

1. CULTURE OF CELL LINES
Basic techniques of culturing mammalian cells, initiation, selection and evolution of cell lines, maintenance of cell lines, phases of cell cycle, growth curve of cells, protocols for subculturing of cells: monolayer and suspension cultures, setting up replicate cultures, established cell lines. Large scale culturing of animal cells.
2. CULTURE ENVIRONMENT
Atmosphere, media- types, components, natural and artificial substrate material

3. PRESERVATION AND CHARACTERISATION OF THE ANIMAL CELL

Maintenance, cryopreservation and storage of cell cultures, culture banks, sources for seed cultures.

4. BIOLOGY OF THE CULTURED CELL AND CELL COUNTING

Transformation, differentiation, deadaptation and dedifferentiation
Cell Counting: hemocytometer, coulter counter, Flow cytometry and Cytofluorometry

5. APPLICATIONS OF ANIMAL CELL CULTURES

REFERENCES:

1. In Vitro Cultivation of Animal Cells (1995) Butterworth – Heinemann
2. Animal Cell Culture (2000) – A Practical Approach John R.W. Masters
3. Culture of Animal Cells – A manual of Basic technique (2005) R.I. Freshney

GBT 211 : CELL AND DEVELOPMENTAL BIOLOGY

MODULE I

Biochemical organization of the cell; diversity of cell size and shape; cell theory, the emergence of modern Cell Biology.

Principles underlying microscopic techniques for study of cells : Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy.

Cellular junctions and adhesions; structure and functional significance of plasmodesmata.

Membrane assembly

Structure and function of cellular organelles; subcellular fractionation; organization of cytoskeleton and nucleus; the plant cell wall.

MODULE II

The eukaryotic cell cycle and its regulation.

Molecular aspects of cell division.

Cell signaling

Cell fusion.

Apoptosis.

Protein localization – synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes, receptor-mediated endocytosis.

Chaperones.

Proteosomes.

MODULE III

Germ cells and fertilization; embryogenesis.

Laying of body axis planes; cellular polarity: differentiation of germ layers.

Morphogens, gradients, concept of compartmentalization and fate mapping

with particular reference to development in *Drosophila*, *Caenorhabditis* and

mammalian systems.

Stem cells and cell differentiation.

Nuclear–cytoplasmic interactions.

Differentiation of cancerous cells and role of proto-oncogenes.

Oncogenes and theories regarding tumour formation.

Ageing.

REFERENCES:

1. The Molecular Biology of the cell. (2002). Albert et al.
2. Molecular Cell Biology. (1986). Darnell, J. et al.
3. Genes X (2010). Lewin, B.
4. Molecular Biology of the Gene. (2003). Watson, J.D., Hopkins,N.H. et al.
5. Developmental Biology. (1997). Gilbert, S.F.
6. Handbook of the Biology of Aging. (1990). Schneider,E.L. & Rowe,J.W.(Eds.)
7. Introduction to Protein Structure (1999). Branden C. & Tooze J.
8. Molecular Cell Biology (2008) Lodish H., *et al*.
9. Cell Biology (1996). Smith, C.A.& Wood, E.J.

GBT 225 : MOLECULAR IMMUNOLOGY

Module I

Recognition of antigens

1. The major histocompatibility complex:

i. Discovery and its role in immune response

ii. Structure of MHC molecules

iii. Binding of peptides to MHC molecules

iv. Genomic organization of the MHC

2. Recognition of antigens by T Lymphocytes
i) Antigen processing and presentation to CD4+ and CD8+ T Lymphocytes.
ii) Antigen receptors and accessory molecules of T Lymphocytes
iii) Effector molecules of T lymphocytes

Maturation, activation and regulation of Lymphocytes

1. Maturation of Lymphocytes
i. General features of Lymphocyte maturation
ii. Formation of functional antigen receptor genes in B & T lymphocytes.
iii. Maturation of B lymphocytes.
iv. Maturation of T lymphocytes.

Module II

2. Activation of T lymphocytes
i) Signal transduction by the T lymphocyte receptor complex – Ras and Rac, Calcineurin and Protein Kinase C signaling.
ii) Activation of transcription factors in T cells
3. Activation of B cells
i. Signal transduction by the B cell antigen receptor complex
ii. CD40 and it's role in T-B cooperation
iii. Bidirectional molecular interactions between T-B cells

4. Immunologic tolerance
i. General features & mechanisms of immunologic tolerance
ii. T Lymphocyte tolerance
iii. B Lymphocyte tolerance
iv. Homeostasis in the immune system: termination of normal immune response

Effector mechanisms of immune responses
i. Cytokines – regulating innate and adaptive immunity and stimulate hematopoiesis
ii. Cell mediated immunity
iii. Humoral immunity

Module III

Immunity in defense and disease
1. Immunity to Microbes –
Immunity to extracellular and intracellular bacteria: Innate and adaptive response, evasion of mechanisms by bacteria
Immunity to fungi, viruses and parasites
Strategies for vaccine development
2. Immunity to tumors
i) Tumor antigens
ii) Immune responses to tumors
iii) Evasion of immune responses by tumors
iv) Immunotherapy for tumours 34

3. Diseases caused by immune responses: hypersensitivity and autoimmunity
i. Mechanisms of autoimmunity
ii. Types of hypersensitivity diseases
iii. Therapeutic approaches for immunologic diseases
iv. Immunosuppression
v. Bone marrow transplantation immunology

REFERENCES:

1. Cellular and Molecular Immunlogy (2000) Abbas A.K., Lichtman A.H. & Pober, J.S.
2. Practical Immunology (2003) Frank C. Hay & O.M.R. Westwood
3. Immunology (2007) Goldsby R.A., Kindt T.J., Osbrne B.A. and Kuby J.
4. Essential Immunology (2005) Roitt I.M. and Delves P.J.
5. Immunology – Roitt I, Bostoff J. Male D.
6. Immunology (2006) Luttmann M, Bratke K, Kupper M & Myrtek D.
7. Manual of Molecular and Clinical Laboratory Immunology (2006)
8. Detrick B, Hamilton R.G. & Folds J.D.

GBL 121: LAB IN ANIMAL CELL CULTURE

1. Sterilization and preparation of glassware, preparation of tissue culture medium and membrane
filtration.
2. Preparation of single cell suspension from spleen or thymus
3. Cell counting and cell viability
4. Setting up of macrophage monolayer and use of inverted microscope
5. Preparation of goat serum
6. Setting up monolayer of tilapia hepatocytes
7. Staining and preparation of permanent slides

REFERENCES :

1. Animal cell culture (2000)-A Practical Approach John R.W. Masters
2. Culture of animal cells – A manual of Basic techniques (2005) R.I. Freshney

GBT 121: Nanobiotechnology

Module I

Introduction to Nano-Biotechnology; Nanotechnology definition and concepts; Cellular Nanostructures;
Nanopores; Biomolecular motors; Criteria for suitability of nanostructures for biological applications

Basic characterization techniques; Electron microscopy; Atomic force microscopy; Photon correlation Spectroscopy

Module II

Thin films; Colloidal nanostructures; Nanovesicles; Nanospheres; Nanocapsules, Nanostructures for drug delivery, concepts, targeting, routes of delivery and advantages, Nanostructures for diagnostics and biosensors; Nanoparticles for diagnostics and imaging; Nanodevices for sensor development

References

1. Multilayer Thin Films, Editor(s): Gero Decher, Joseph B. Schlenoff Publisher: Wiley-VCH Verlag GmbH & Co.
KGaA ISBN: 3527304401
2. Bionanotechnology: Lessons from Nature Author: David S. Goodsell Publisher: Wiley-Liss ISBN: 047141719X
3. Biomedical Nanotechnology Editor: Neelina H. Malsch Publisher: CRC Press ISBN: 0-8247-2579-4

Semester IV

GBT 331: Advances in Plant Biotechnology

Module I

Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid.

Genetic Transformation
Agrobacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer -PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectablemarkers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.

Molecular Mapping & Marker Assisted Selection (MAS)

Quantitative and qualitative traits; MAS for genes of agronomic importance, e.g. insect resistance, grain quality and grain yield; Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning.

Module II

Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance
Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance

Genetic Engineering for Plant Architecture and Metabolism
Seed storage proteins; Protein engineering; Vitamins and other value addition compounds; Source-sink relationships for yield increase; Post-harvest bioengineering; Plant architecture; Flowering behavior

Plants as Biofactories
Concept of biofactories; Fermentation and production of industrial enzymes, vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation

Module III

Plant Genomics
Identification of candidate genes using genetic information (positional cloning), using biochemical and expression analysis (microarray analysis, proteomics, metabolomics); Characterization and functional analysis of candidate genes: transformation, mutant populations, knockout systems; Heterologous expression systems; Protein analysis; Bioinformatics and databases; Genoinformatics.

Eco-biotechnology
Biosensors; Biofuels; Marine biofarming; Plant genetic resources; Patenting of biological material; Plant breeders rights (PBRs) and farmers rights; Biosafety and containment practices.

References

1. Adrian Slater, Nigel Scott and Mark Fowler, Plant Biotechnology: The genetic manipulation of plants, 1st Edition, Oxford University Press,2003
2. Edited by BR Jordan, 2nd Edition, The Molecular Biology and Biotechnology of Flowering, CABI, 2006.
3. Neil Wille, Phytoremediation: Methods and Reviews, 1st Edition, Humana Press, 2007.
4. Denis Murphy, Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture, Cambridge University Press, 2007.

GBT 332: Advances in Animal Biotechnology

Module I

Stem cell biology. Molecular principles underlying pluripotency, Human embryonic stem cell characterization, Reprogramming Somatic Cells into Induced Pluripotent Stem Cells, Differentiation of human embryonic stem cells to cardiomycetes, Large scale culture of pluripotent stem cells, human embryonic stem cell derived tissue transplantation therapy, Use of umbilical cord stem cells. Fetal mesenchymal stem cells, From stem cells to neurons, stem cells of liver, cartilage, tendon, ligament repair with stem cells, Ethics of stem cell technology.

Module II

General features of eukaryotic expression and vector systems. Gene transfer to animal cells Transgenic mice methodologies, Transgenic poultry, Transgenic Fish, Embryo transfer technology, Gene targeting, Cloning live stock by nuclear transfer, Transgenic live stock, Ethics of cloning Disease resistant transgenics, animal models for disease study, Pharming, improving milk quality, improving traits, Xenografts, Toxological applications, knock outs

Module III

Animal models used in genetics and genomic studies Drosophila, *C.elegans*, Zebra fish, A. thaliana.

References

1) Bongso A and Lee EH . Stem cells from bench to bed side World Scientific publisher 2'nd Ed

GBT 131 : Bioentrepreneurship

Module I

Finance and Marketing

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; Negotiations/Strategy With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer

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 Dispute resolution skills;

Module II

Fundamentals of Entrepreneurship

Support mechanism for entrepreneurship in India 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. E-business setup, management. 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. External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking

GBT 231 : BIOSAFETY AND IPR

Module I

Introduction to Intellectual Property

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP
IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS
Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.);

Module II

Basics of Patents
Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application
Patent filing and Infringement

Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US
Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives
Patent infringement- meaning, scope, litigation, case studies and examples

Module III

Biosafety
Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines – 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.

REFERENCES

1. Intellectual property rights in Biotechnology. A status report (1993). Singh, K.
2. Biotechnology and Patent laws:patenting living beings (2008) Sreenivasulu, N.S. and Raju C.B. Manupatra Publishers.
3. Patents for Chemicals, Pharmaceuticals a nd Biotechnology:Fundamentals of Global Law, Practice and Strategy (2010) Grubb P. W. Grubb, P. L. Thomsen, P. R. Oxford University Press.
4. Patent law in Biotechnology, chemicals & pharmaceuticals. (1994) Harold C. Wegner Stockton Press
5. A User's Guide to Patents (2007) Trevor M. Cook. Tottel Publishing.
6. Intellectual property law (2008) Lionel Bently, Brad Sherman. Oxford University Press.
7. Biosafety and bioethics (2006) Rajmohan Joshi. Gyan Publishing House.
8. Laboratory biosafety manual. (2004). World Health Organization. WHO press, 2004.
9. Biological safety: principles and practices (2000) Diane O. Fleming, Debra Long Hunt. ASM Press.
10. CRC handbook of laboratory safety. (2000)A. Keith Furr. CRC Press.