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Paper VII: Animal cell science Technology & IPR

Basic understanding for cell culture: Structure and organization of animal cell, Cell physiology. Primary and established cell line cultures. Biology and characterization of the cultured cells and measuring their growth.

Tools and Culture Media: Equipments and materials for animal cell culture technology. Introduction to the balance salt solutions and simple growth medium. Brief account on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements, Serum & protein free defined media and their application.

Techniques of cell culture: Basic techniques of mammalian cell culture *in vitro*; disaggregation of tissue and primary culture; maintenance of cell culture; cell separation. Scaling-up of animal cell culture, measurement of viability and cytotoxicity. Cell synchronization. Cell cloning, micromanipulation and types of cloning. Stem cell culture, embryonic stem cells and their applications. Measurement of cell death. Apoptosis. Three dimensional culture and tissue engineering.

Mammalian Cell transformation : Establishment of Immortal cell lines, transfection, selection by selectable markers, gene amplification for high level protein expression. Specialized methods to transfer difficult cell types; Uses of viral vectors, Vaccinia and Baculovirus and Retrovirus in gene transfer; and use of antisense RNA and DNA in controlling gene function. Mice as the experimental material for gene introduction.

Impact of Recombinant DNA on human Genetics: Mapping and cloning human disease genes- Positional cloning, subchromosomal mapping and markers, in situ hybridization to chromosomes and RFLP.

Applications of Animal cell and Recombinant DNA technology: Cell culture based vaccines. Somatic cell genetics. Organ and histotypic cultures. Development of Transgenic animals (Mice, Cattle, Sheep, Goat, Pigs, Birds and Fish) and their uses. DNA- based diagnosis of genetic diseases; human somatic cell gene therapy for single-gene disorders.

Intellectual property rights: Meaning, Evolution- classification and forms. Importance of IPR's in the field of science and technology. Patents- concepts and principles of patenting, patentable subject matter, Procedure of obtaining patents, rights of patents, infringement of patent rights, remedies for infringement of patent rights- patentability and emerging issues.

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Suggested Laboratory Exercises:

1. Preparation of tissue culture medium and membrane filtration.
2. Preparation of single cell suspension from spleen and thymus.
3. Cell counting and cell viability.
4. Macrophage monolayer from PEC,and measurement of pathogenicity activity.

5. Trypsinization of monolayer and subculturing.
6. Cryopreservation and thawing.
7. Measurement of doubling time.
8. Role of serum in cell culture.
9. Preparation metaphage chromosome from cultured cells.
10. Isolation of and demonstration of apoptosis of DNA laddering.
11. MTT assay for cell viability and growth.
12. Cell fusion with PEG.
13. Any other practical based on theory syllabus

Suggested Readings:

1. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
2. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
3. Froshney, RI. Culture of Animal Cells,(3rd Edition), ,Wiley-Liss.
4. Mesters, JRW. (Ed) Animal Cell Culture-Practical Approach,Oxford.
5. Basega, R. (Ed), Cell Growth and Division:A Practical Approach, IRL Press.
6. Butler, M. & Dawson, M. (Eds) Cell Culture Lab Fax.Eds.,Bios Scientific Publications Ltd. Oxford.
7. Martin Clynes. M. (Ed). Animal Cell Culture Techniques. Springer.
8. Jenni, Mathur P. and Barnes, D (Eds). Methods in Cell Biology,Vol.57,Animal Cell Culture Methods. Academic Press.
9. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
10. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
11. Kumar, HD. (1998). Modern Concept of Biotechnology, Vikas Publlishing House, New Delhi
12. Krattiger et al (2007) "Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices", Managing Innovation for a Better World
13. Hahn, RW. (2005). *Intellectual Property Rights in Frontier Industries: Software and Biotechnology*, AEI Press.
14. Miller, Raphael, A. and Michael HD. (2000) *Intellectual Property: Patents, Trademarks, and Copyright*. 3rd ed. New York: West/Wadsworth.

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Paper VIII : Plant Biotechnology

Tissue culture: Principles, Concept, History of development of plant tissue culture. Concept of ncy, PTC laboratory facilities, operation and management, General methodology. Different dia and their nutritional components, media preparation and sterilization techniques. Aseptic es and preparation of explants, histological techniques for plant tissue culture. servation and slow growth for germ plasm preservation.

Tissue culture technology: Shoot morphogenesis and organogenesis, rooting, hardening and nsfer: Micropropagation, production of virus free plants, callus and suspension cultures, ell culture. Ovary, anther and microspore culture for production of haploid plants. Somatic genesis, synthetic seeds and its cryopreservation. Plant tissue culture as a technique to produce

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novel plants, somaclonal variations. Overview of Plant Tissue Culture Applications.

Protoplast technology: Protoplast isolation, purification, viability tests, plating efficiency, culture, Somatic cell hybridization, selection of hybrid, cybrids and their regeneration.

Plant transformation (Recombinant DNA) technology: Tools and techniques, Vectors for plant transformation (Viral and Bacterial), Basic molecular characteristics of *Agrobacterium*. Basis of tumor and hairy-root formation; Characteristic features of vectors (Co-integrative and binary vectors, Ti, Ri plasmids, 35S and other promoters and terminators, selectable markers, reporter genes, origin of replication etc.).

Agrobacterium-mediated plant transformation: Cloning of selected gene, its integration into *Agrobacterium*. *Agrobacterium*-mediated gene transfer - mechanism of T-DNA transfer and its integration into plant genome, role of virulence gene, selection of transformed cells/ tissues, expression of the integrated gene in plants. Multiple gene transfer. Practical applications of *Agrobacterium*-mediated gene transfer.

Methods of Direct gene transfer and Storage: Particle bombardment, electroporation and micro injection. Transgenic gene incorporation, stability and expression; gene silencing. Cryopreservation and Gene banks.

Plant Breeding: Brief idea about conventional Plant Breeding Methods- Character identification, incorporation (hybridization), selection and release of variety; Role of

Molecular markers: RFLP, RAPD, STS, SCAR, SSCP, AFLP in plant breeding applications. Green house and green-home technology.

Transgenic approaches to crop improvement: Resistant against biotic (virus, fungi, bacteria, nematode, insect, weed) and abiotic stress (salinity, drought, herbicide, cold, metals), longer shelf life. Improvement of crop yield and quality - golden rice and other developments. Extension of flower life, pigmentation and fragrance.

Manufacture of valuable products: Industrial applications of plant cell culture; Plant cell culture and biosynthesis of secondary products; Manufacture of - antigens, antibodies, edible vaccines, enzymes, proteins.

Suggested Laboratory Exercises:

1. Preparation of Stock solutions for MS medium.
2. Preparation of medium.
3. Micro propagation technique
4. Surface sterilization and Organ culture.
5. Callus induction, propagation, and differentiation
6. Organogenesis- Shoot and root formation and their organic connection.
7. Hardening and transfer of plants to soil.
8. Study of somatic embryogenesis.
9. Anther culture, production of Haploids.
10. Ovary culture

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11. Somatic embryogenesis using appropriate explants and Preparation of synthetic seeds
12. Protoplast isolation and culture.
13. Demonstration of protoplast fusion employing PEG.
14. Cytological examination of regenerated plants.
15. Isolation & Identification of Sec. metabolite from Plant Cell Cultures.
16. Agrobacterium culture,selection of transformants,reporter gene(GUS)assays.
17. Any other practical based on theory syllabus

Suggested Readings:

1. Bhojwani, S.S. and Razdan, M.K. (1996). Plant Tissue Culture : Theory and Practice (a revised edition). Elsevier Science Publishers, New York. USA.
2. Slater A, Scott N, Fowler M (2010). Plant biotechnology: the genetic manipulation of plants. Oxford: Oxford University Press.
3. Hammond, J. McGarvey P. and Yusibov V.(Eds.) (2000). Plant Biotechnology. Springer Verlag. Germany.
4. Fu,T –J., Singh, G. and Curtis, WR. (Eds) (1999). Plant Cell and Tissue Culture for the Production of Food Ingredients. Kluwer Academic/Plenum Press.
5. Chawla, HS. (1998). Biotechnology in Crop improvement. International Book Distributing Company.
6. Henry, RJ. (1997). Practical Application of plant Molecular Biology. Chapman and hall.
7. Butenko, RG. (2000). Plant Cell Culture, University Press of Pacific.
8. Collin, H.A. and Edwards, S. (1998). Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
9. Dixon, RA. (Ed.) (1987). Plant Cell Culture :Practical Approach. IRL Press, Oxford.
10. George, EF. (1993). Plant Propagation by Tissue Culture. Part 1. The Technology, 2nd edition. Exegetics Ltd., Edington, UK.
11. Hall, RD. (Ed.) (1999). Plant Cell Culture Protocols. Humana Press, Inc., New Jersey, USA.
12. Shaw, CH. (Ed.) (1988). Plant Molecular Biology: A Practical Approach, IRL Press, Oxford.
13. Smith, RH. (2000). Plant Tissue Culture: Techniques and Experiments. academic press, New York.
14. Kumar, A. and Roy, S. (2006). Plant Biotechnology & is applications in Tissue Culture. I.K. International Pvt. Ltd.
15. Kumar, A. and Roy, S. (2011). Plant Tissue Culture and Applied Biotechnology, Aavishkar Publishers, Jaipur.
16. Mascarenhas, AF. (1991). Handbook of Plant Tissue Culture, ICAR, New Delhi.
17. Ramawat, KG. (2000). Plant Biotechnology, S. Chand & Co. Ltd. New Delhi.
18. Rajdan, MK. (1993). An Introduction to Plant Cell Culture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
19. Narayanaswamy, S. (1994). Plant Cell and Tissue Culture. Tata McGraw-Hill Pub. Com. Ltd. New Delhi.
20. Ammirato, PV, Evans, DA, Sharp, WR. And Yamada, Y. (1984). Hand Book of Plant Cell Culture, Vol. 1-3, Macmillan Pub. Co. NY & Collier Macmillan Pub. London.
21. Gupta, PK. (2010). Plant biotechnology, Rastogi Pub. Meerut.
22. Natesh,S, Chopra, VL. And Ramachandran, S. (1987). Biotechniques in Agriculture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

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Paper IX: Industrial Biotechnology and Bioprocess Engineering

Selection of industrial microorganisms: industrial cultures- bacteria, algae, fungi and actinomycetes. Primary and secondary screening, Isolation, maintenance and preservation, microbial growth and death kinetics of industrial microorganisms. Strain development- mutation, selection and recombination. Immobilisation of microbial cells and their application.

Microorganisms in Agricultural biosafety: Biofertilizers and their application, biopesticide in disease management; Rhizobacteria for plant growth promotion and disease managment including parasitic nematodes; Bacteria and soil fungi in plant disease management.

Fermentation process: Fermentor systems- types; Fermentation process and factors affecting fermentation process. Commercial fermentation: Design- overview of aerobic and anaerobic fermentation process. Design of fermentation media, Substrates used as carbon and nitrogen sources. Analysis of batch, fed batch and continuous bioreactions, biotransformation, Downstream Processing.

Production of microbial fermentation products: Organic acids (lactic acid, acetic acid & gluconic acid), Polyhydroxyalkanoic acids; Solvents (acetone and butanol). Amino acid (Aspartic acids, lysine, glutamic acid), Enzymes (proteases, amylases, lipases, cellulases & pectinolytic enzyme). Alcohol and beverages (acetone, n- butanol, ethanol; beer, wine). Application of fungi for biodegradation of cellulosic waste and ethanol production.

Metabolic engineering: Plant secondary metabolites; control mechanisms and manipulation of shikimic acid pathway; control mechanisms and manipulation of phenylpropanoid pathway. Organic acids:Propanediols, butanediol, succinic acid, propionic and butyric acids.

Health care products and food additives: Mushroom cultivation technology. Antibiotics- penicillin, streptomycin, tetracycline and erythromycin. Vaccines- BCG, hepatitis- B & recombinant vaccines; Vitamins- B_{12}, D & C; dairy products- cheese, yoghurt and other products., health care and environment.

Introduction to food technology: principles of food processing, sterilization and pasteurization of food products. Elementary idea of bottling, canning and packing of different types of food products (liquid, powdered and semi-cooked), technology of typical food products (Bread, cheese, idly); food preservation.

Engineering Industrial Products: alkaloids, industrial enzymes, Bioplastics and biopolymers, polyhydroxybutyrate, therapeutic proteins. Biosensors- application in the industry.

Suggested Laboratory Exercises:

1. Isolation of industrially important microorganisms for microbial processes.
2. Comparative studies of Ethanol production using different substrates.
3. Microbial production of citric acid using *Aspergillus niger*.
4. Microbial production of antibiotics (Penicillin).
5. Cultivation techniques of mushrooms.
6. Selection of efficient PGPR and mycorrhizae and their affect on growth
7. Isolation and preservation of industrially important microorganisms for microbial processes.
8. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganisms for design of a sterilizer.

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9. Comparative studies of Ethanol production using different substrates.
10. Production and estimation of Alkaline Protease.
11. Use of alginate for cell immobilization.
12. Microbial production of single cell protein.
13. Preparation of list of the hazardous chemicals and their biosafety measures.
14. Any other practical based on theory syllabus

Suggested Readings:

1. Aiba, S., Humphrey AE. and Millis, N.F. (1973). Biochemical Engineering(2nd Edition), Univ.of Tokyo Press, Tokyo.
2. Atkinson, B. (1974). Biochemical Reactors, Pion Ltd. London.
3. Casida Jr., L.E. (1996), Industrial Microbiology, New Age International (P) Ltd.
4. Bailey, JE. and Ollis, DF. (1986) Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill Book Co.,New York.
5. Enfors, S-O. and Häggström, L. (2000). Bioprocess Technology: Fundamentals and Applications, KTH, Stockholm.
6. Jackson, AT., (1991). Process Engineering in Biotechnology, Prentice Hall, Engelwood cliffs, NJ, USA.
7. Shuler, ML. and Kargi, F., (1992). Bioprocess Engineering: Basic Concepts, Prentice Hall, Engelwood Cliffs.
8. Stanbury, PF., Whitaker, A. and S. J. Hall, SJ. (1995). Principles of Fermentation Technology, Pergamon Press, Oxford.
9. Nielson, J. and Vissadsen, J., (). Bioreaction Engineering Principles, Plenum Press.
10. Doran, PM. (1995). Bioprocess Engineering Principles, Academic Press.
11. Shuler, ML.(Ed.), (1989). Chemical Engineering Problems in Biotechnology, AICHE, New York.
12. Lee, JM. (2009). Biochemical Engineering, Prentice Hall Inc.
13. Vieth, WF., (1999). Bioprocess Engeering-Kinetics, Mass Transport, Reactors and Gene Expression, John Wiley.& Sons Inc.
14. Rai, B. and Dkhar, MS. (1998). New trends in Microbial Ecology, Deptt. Of Botany, NE Hill Univ. Shillong & ISCON, Varanasi.
15. Rai, B., Upadhyay, RS. and Dubey, NK. (1998). Trends in Microbial Exploitation, ISCON, Varanasi.
16. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
17. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
18. Kumar, HD. (1998). Modern Concept of Biotechnology, Vikas Publishing House, New Delhi
19. Yadav,, PR., Rao, MG. and Jana, T. (2005). Industrial Biotechnology, Discovery Publication
20. Soetaert, W. and Vandamme, EJ. (eds.) (2010). Industrial Biotechnology, Wiley-VCH Verlag GmbH & Co, Weinheim, Germany.

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Paper X: Genetic Engineering

Gene engineering tools and their applications: Restriction enzymes, modification enzymes (ligases and other enzymes needed in genetic engineering), DNA and RNA markers. Gene Cloning Vectors- Plasmids, bacteriophages, phagemids, cosmids. Artificial chromosome vectors (YAC, BAC, MAC), CHEF analysis, virus derived vectors-SV40, M13, retroviral vectors, and their applications.

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Nucleic Acid Sequencing and Amplification : Sequencing methods and its Applications- Maxim & Gilbert's, and Sanger's methods; Pyrosequencing, Thermal PCR, Shot gun sequencing and Automated method. Nucleic Acid purification, amplification and Yield Analysis; PCR: types & applications.

Gene manipulation: cDNA Synthesis and its Cloning; mRNA enrichment, DNA primers, linkers & adaptors, Library (cDNA and Genomic) construction and screening. Alternative Strategies of Gene Cloning, Two and three hybrid systems, cloning of genes in expression vectors. Nucleic acid microarray arrays.

Study of gene Expression & Reulation: DNA transfection, Northern blot, Primer extension, SI mapping, RNase protection assays, Reporter assays.

Southern and Western blotting, DNA fingerprinting, Chromosome walking, Southern and Fluorescence *in situ* hybridization.

Mutagenesis, Protein Engineering & Processing of Recombinant proteins - Directed Mutagenesis- Oligonucleotide with M13 DNA, PCR amplified oligonucleotide and Random mutagenesis. Protein Engineering: adding disulfide bonds, reducing number of free sulfhydril residues, changing aminoacids, increasing and modifying enzymatic activity. Processing of Recombinant proteins: Purification and refolding, characterization of recombinant proteins, stabilization of proteins.

T-DNA and Transposon Tagging: Role of gene tagging in gene analysis, T-DNA and Transposon tagging, Identification and isolation of genes through T-DNA or transposon. Transgenic and Gene Knockout Technologies. Targeted gene replacement, Chromosome engineering.

Expression Strategies for Heterologous Proteins: Vector engineering, host engineering, in vitro transcription and translation, expression in bacteria, yeast, insects and insect cells, expression in mammalian cells and plants.

Gene Therapy-Vector engineering. Strategies of gene delivery, gene replacement/ augmentation, gene correction, gene editing gene regulation and silencing.

Application of genetic engineering: Uses of Transgenic plants and animals; production of recombinant pharmaceuticals, disease diagnoses and nanotechnology.

Suggested Laboratory Exercises

1. Growth characteristics of E. coli using plating and turbidometric methods.
2. Bacterial culture and antibiotic selection on media.
3. Isolation of plasmid from E. coli by alkaline lysis method and its quantitation spectrophotometrically.
4. Amplification of DNA by PCR process
5. Restriction enzyme digestion of genomic DNA from *E.coli*.
6. Restriction enzyme digestion (*EcoRI*) of plasmid DNA
7. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
8. RFLP analysis
9. RAPD analysis
10. Demonstration of DNA fingerprinting.
11. Restriction digestion of the plasmid and estimation of the size of various DNA fragments & Construction of Restriction digestion map.
12. Cloning of DNA fragment in a plasmid vector.
13. Transformation of the given bacterial population and selection of recombinants.
14. Co-cultivation of the plant material (e.g. leaf discs) with *Agrobacterium* and study GUS activity histochemically.

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15. Any other practical based on theory syllabus.

Suggested Reading:

1. Sambrook, J., Fritsch, EF. and Maniatis, T. (2000). Molecular Cloning: [illegible]tory Manual Cold Spring Harbor Laboratory Press,New York.
2. Glover, DM. and Hames, BD. (1995). DNA Cloning: a practic[illegible] IRL Press Oxford.
3. Kaufman, PB., Wu, W., Kim, D. and Cseke, LJ. (1995). Molec[illegible]ethods in Biology and Medicine CRC Press.Florida.
4. Berger, SL. and Kimmel, AR. (1998). Guide to Molecular Clonin[illegible] Academic press Inc. San Diogo.
5. Gooddol, DV. (1990). Gene Expression Technology Academic Pres[illegible]n,1990.
6. Mickloss, DA. and Greyer, GA. (1990). DNA Science A Firs[illegible]combinant Technology, Cold Spring Harbor Laboratory Press, New York.
7. Primorso, SB. (1994). Molecular Biotechnology (2nd Edn.), Blackw[illegible] Publishers, Oxford.
8. Davies, JA. and Roznikolf, WS. (1992). Milestones in Biotechnology. Classic papers on genetic Engineering Butterworth-Heinemann, Boston.
9. Walker, MR. and Repley, R. (1997). Route Maps in Gene Technology. Blackwell Science Ltd.Oxford.
10. Kingsman, SM. and Kingsman, AJ. (1998). Genetic Engineering : An Introduction to gene analysis and exploitation in eukaryotes. Blackwell Scientific blications.Oxford,1998.
11. Glick BR. and Thompson, JE. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
12. Glover, D.M. and Hames, B.D. (Eds.) (1995). DNA Cloning 1 : A Practical Approach, Core Techniques, 2nd edition. PAS, IRL Press at Oxford University Press, Oxford.
13. Hackett, PB., Fuchs, JA. and Meesing, JW. (1988). An Introduction to Recombinant DNA Techniques : Basic Experiments in Gene Manipulation. Benjamin/Cummings Publishing Co., Inc. Menlo Park, California.
14. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
15. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.

M. Sc. BIOTECHNOLOGY (FINAL)

[illegible]PER XI: Environmental Biotechnology, Biosafety, Ethics and Research Methodology

Natural resource and its management, Sources of water pollution and biological treatment [illegible]s and their microbiology: Aerobic Processes-Oxidation ponds, Trickling filter, Activated [illegible]rocess, rotating discs, rotating drums; Anaerobic processes-Anaerobic digestion, anaerobic [illegible]p-flow anaerobic sludge blanket reactors.

[illegible]ology of degradation of Xenobiotics in Environment - Oil pollution, surfactants, [illegible]s. Solid wastes: Sources and management (composting, vermiculture and methane [illegible]on), bioremediation of contaminated soils and waste-land and groundwater. Reclamation of [illegible]vastelands, oil spill.

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Global environmental problems: Green house effect and acid rain, their effects and biotechnological approaches for management. Biofuels, Global warming; Methodology of environmental management- the problem solving approach, its limitations. Biodiversity and its conservation; Intraspecific variations in crop plants, molecular characterization of variations.

Human population growth and global food prospects: Food security and availability of food, Molecular basis of genetic modification and crop improvement programmes, GM food crops, Biotechnology in controlling crop diseases, weeds, insects and pests. Biopesticides in integrated pest management. Seed- seed banks, terminator gene technology and implications, International and local regulations.

Biosafety: Security measures, laboratory information management system (LIMS). Laboratory safety- safety policies. health hazardous compounds, chemicals (xenobiotic compounds), solvents, poisons, isotopes, radioactive materials, explosives and biological strains (bacterial, fungal etc.) and their waste management. Biosafety cabinet, Storage of hazardous material and disposal of biological and radioisotope wastes.

Ethical Issues: introduction- causes of unethical acts, ignorance of laws, codes, policies and procedures, recognition, friendship, personal gains. Professional ethics - professional conduct. Ethical decision making, ethical dilemmas. Teaching ethical values to scientists, good laboratory practices, good manufacturing practices, laboratory accreditation.

Research Methodology: introduction- Basic research, applied research, need based research. Identification of the problem, defining the problem. Research project planning. Literature search- information sources, library resources-books, journals, abstracts hand books, procedure manuals, encyclopedias, annual reports, data banks, CDROMS, online literature search- internet access, websites, directories of information resources.

Progress of research- evaluation of results, statistical approach, comparison with existing methodologies, validation of findings, research communications, impact factor of journals.

Suggested Laboratory Exercises:

1. Detection of coliforms for determination of the purity of potable water.
2. Determination of total dissolved solids of water.
3. Determination of dissolved oxygen concentration of water sample.
4. Determination of biological oxygen demand(BOD)of a sewage sample.
5. Determination of chemical oxygen demand(COD)of sewage sample.
6. Determine the efficiency of removal of air pollutant using fibrous air filter.
7. Isolation of xenobiont degrading bacteria by selective enrichment technique.
8. Test for the degradation of a aromatic hydrocarbons by bacteria.
9. Survey of degradative plasmids in microbes growing in polluted environment.
10. Effect of Sulphur dioxide on crop plants.
11. Estimation of heavy metals in water/soil by Atomic absorption spectrophotometry.
12. Estimation of nitrate in drinking water.

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13. Study on biogenic methane production in different habitats.
14. Any other practical based on theory syllabus

Suggested Readings:

1. Chrispeel, MJ. and Sadava, DE. (2003). Plant, Gene and Crop Bitechnol. ASPB.
2. Kocher, SL. Economic Botany.
3. Metcall, R. and Eddy. (2003).Wastewater Engineering-Treatment, Disposal. Inc.,Tata McGraw Hill, Delhi.
4. Moo-Yound (Ed-in-chief), (1999). Comprehensive biotechnology, vol.4, M. Pergamon Press, Oxford.
5. De, AK. (2004). Environmental Chemistry. Willey Eastern Ltd.,New Delhi.
6. Allsopp, D. and K.J.Seal, KJ. (). Introduction to Biodeterioration. ELBS/Edward Arnold.
7. Cookson, JT. (1995). Bioremediation Engineering: design and Application. McGraw-Hill,Inc.
8. Cheremisinoff, N P. (). Biotechnology for waste and wastewater treatment.
9. Jogdand, SN. (1995), Environmental Biotechnology Himlaya Publishing House
10. Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, California: Sage Publications.
11. Creswell, J. (2003). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, California: Sage Publications.
12. John W. Creswell, 2009, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Third Edition, www.sagepub.com, ISBN: 978-1-4129-6557-6
13. Dahlia K. Remler, Gregg G., Van Ryzin, R. (2011). Research Methods in Practice, Strategies for Description and Causation. , www.sagepub.com, ISBN: 978-1-4129-6467-
14. Glenn, MacDonald, L. (2011).Ethical Issues in Genetic Engineering and Transgenics
15. McGee, G. "Primer on Ethics and Human Cloning" http://www.actionbioscience.org/biotech/mcgee.html
16. "Primer on Ethics and Crossing Species Boundaries "http://www.actionbioscience.org/biotech/baylis_robert.html
17. Grey, ST. "Genetic Engineering and Xenotransplantation" http://www.actionbioscience.org/biotech/grey.html
18. Kolehmainen, S.M. "The Dangerous Promise of Gene Therapy" http://www.actionbioscience.org/biotech/kolehmainen.html
19. Sherlock, R. and Morrey, JD. (2002). -Ethical issues in biotechnology, Rowman & Littlefield Publishers, Inc., Maryland.
20. Paul B. Thompson (2007). Food biotechnology in ethical perspective, The Springer, 2nd Ed., The Netherlands.

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Paper XII: Elective Paper

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