University of Rajasthan
Jaipur

SYLLABUS

M.SC.

(BIO-TECHNOLOGY)

(Annual Scheme)

M.Sc. (Previous) Examination 2020

M.Sc. (Final) Examination 2021

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UNIVERSITY OF RAJASTHAN, JAIPUR

M.Sc. Bio-Technology
(Annual Scheme)

- M.Sc. Previous
- M.Sc. Final
- Scheme of Examination
- Distribution of Papers & Marks

M.Sc. Previous

Paper I	Cell Biology
Paper II	Biological Macromolecules, Enzymology & Biotechnique
Paper III	Genetics and Computer applications
Paper IV	Molecular Biology
Paper V	Microbial diversity, Physiology and Genetics
Paper VI	Pathogenesis, Virology and Immunology
Practical I	Based on theory papers I,II and III
[illegible]	Based on theory papers IV, V and VI

M.Sc. Final

Paper VII	Animal Cell Science Technology & IPR
Paper VIII	Plant Biotechnology
Paper IX	Industrial Biotechnology & Bioprocess Engineering
Paper X	Genetic Engineering
Paper XI	Environmental Biotechnology, Biosafety, Ethics and Research Methodology
Paper XII	Elective Paper (Internal evaluation)
Practical III	Based on theory papers VII to IX
Practical IV	Based on theory papers X & XI
Dissertation & Industry visit	

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Scheme of Examination

1. The course of M.Sc. (Biotechnology) shall be spread over two academic years to be called M.Sc. Previous and M.Sc. Final.
2. *Each theory paper shall carry 100 marks and will be of 3 hrs duration. Minimum passing marks shall be 36.*
3. *The theory question paper will be divided into two parts A and B. Part A of question paper shall be compulsory and contain 10 (ten) very short answer type questions of 20 words covering entire syllabus, each carrying 2 (two) marks, with a total of 20 marks.*
4. *Part B of question paper will have 4 questions having 100% internal choice. Each question will carry 20 marks, with a total of 80 marks.*
5. In each practical paper 10% marks will be reserved for the practical record and 10% marks for the viva voce examination. The practical record will also have a typed record of one seminar delivered by the student.
6. The Elective paper in the M.Sc. Final year will be based on detailed review report on one of the courses listed in the syllabus. The student will make a complete report in about 100 pages that shall be evaluated by the course coordinator and one internal teacher. The marks will be awarded internally.
7. Dissertation: The project work will involve in depth practical work on a problem suggested by the supervisor of the candidate. The evaluation of the dissertation will be done by the external examiner and carry 50 marks. The dissertation submitted by the candidate shall be evaluated by one external expert, Head of the Department and supervisor of the candidate. The seminars, in-plant training and industrial visit reports will also be submitted by the candidate to the Head of the Department who will submit these to the external examiner. The examination shall be held in the department. The dissertation etc. will NOT be required to be mailed to the external examiner. The distribution of the marks will be as under.

Dissertation	50 marks
Viva voce	25 marks
Total	75 marks

Minimum pass marks will be 36% in theory, as well as, practical. First division (60%) and second division (48%)

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Distribution of Papers & Marks

M.Sc. Previous

Paper I	Cell Biology	100 marks
Paper II	Biological Macromolecules, Enzymology & Biotechnique	100 marks
Paper III	Genetics and Computer applications	100 marks
Paper IV	Molecular Biology	100 marks
Paper V	Microbial diversity, Physiology and Genetics	100 marks
Paper VI	Pathogenesis, Virology and Immunology	100 marks
Practical I	Based on theory papers I,II and III	75 marks
Practical II	Based on theory papers IV, V and VI	75 marks
	Total	**750 marks**

M.Sc. Final

Paper VII	Animal Cell Science Technology & IPR	100 marks
Paper VIII	Plant Biotechnology	100 marks
Paper IX	Industrial Biotechnology & Bioprocess Engineering	100 marks
Paper X	Genetic Engineering	100 marks
Paper XI	Environmental Biotechnology, Biosafety, Ethics and Research Methodology	100 marks
Paper XII	Elective Paper (Internal evaluation)	50 marks
Practical III	Based on theory papers VII to IX	75 marks
Practical IV	Based on theory papers X & XI	50 marks
Dissertation & Industry visit		75 marks
	Total	**750 marks**
	Grand Total marks	**1500 marks**

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M. Sc. Biotechnology Previous

Paper I: Cell Biology

The Dynamics of cell, shape and motility: Structural organization of the plant, animal and microbial cells, Cytoskeleton, microtubules and microfilaments, motor and flagellar movements.

Cell wall, plasma membrane and plasmodesmata: Structure and functions, biogenesis, growth models and functions, ion carriers, channels and pumps, receptors. Role in [illegible] and macromolecules across membranes, comparison with gap junctions. Plant cell adhesion & plasmodesmata.

Other Cellular organelles: Structure and functions of micro-bodies, Golgi apparatus, ribosomes, lysosome, endoplasmic reticulum.

Plant vacuole: Structure and function

Nucleus: Structure, nuclear envelope (karyotheca), nuclear pores, nuclear lamina, nucleolous and nuclear matrix.

Chloroplast and mitochondria: Fine Structure and function of the organelles, their electron transport systems, import of nuclear encoded proteins, ATP synthases, structure, organization and function of mitochondrial and chloroplast genomes, mechanism of organelle gene expression, diversity and evolution of organelle genomes.

Chromatin organization : Chromosome structure and packaging of DNA, nucleosome organization, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, specialized types of chromosomes, polytene, lampbrush, B-chromosomes , supernumerary chromosomes. Molecular basis of chromosome pairing.

Molecular cytogenetics : Nuclear DNA content, C-value paradox, cot curve and its significance, multigene families and their evolution, in situ hybridization - concept and techniques, computer assisted chromosome analysis, chromosome microdissection and microcloning, flow cytometry and confocal microscopy in karyotype analysis.

Cell Cycle and Mechanics of cell division: Cell cycle control mechanism -Negative and Positive controls & extra cellular controls, Role of cyclins & cyclin depended kinases (CDKs), Cytokinesis and cell plate formation. The events of m phase, CDK & cyclin B leading to Metaphase. The spindle assembly check points leading to Anaphase. DNA damage check point controlled by P 53 protein. Map & mitogen-activated protein kinase (MAPK) : Erk1& Erk2, Ras (mitogen activated protein kinases).

Mechanism at different stages of mitosis: Cohesins and condensins in chromosome segregation, Microtubules in spindle assembly, Structure of kinetochore, centrosome and its functions, Sister chromatid separation. Cytokinesis, actin & myosin in the generation of contractile ring, tonatic metaphase.

Meiosis- Significance, Chiasma formation- Synaptonemal complex, Recombination during meiosis- Recombination nodules.

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Apoptosis (Programmed cell death): Mechanism of apoptosis, Apoptosis triggered by internal & external signals, Apoptosis inducing factors, cancer, oncogenesis & its mutations.

Cell communication and Signal transduction: Overview of extra cellular signaling

signal molecules- hormones, neurotransmitter proteins, environmental factors

Second messengers and their role in signal transduction - lipid and phosphatidyl inositol derived second messengers & Role of calcium as second messenger

Cell surface receptors in signal transduction: G-protein coupled receptor – structure and function, Ion channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK).

Interaction and regulation of cell signaling pathways - bacterial and plant two component signaling system, bacterial chemotaxis and quorum sensing.

Suggested Laboratory Exercises:

1. EM study of cell organelles.
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with calcofluor
4. Study of stages in cell cycle.
5. Mitosis and Meiosis.
6. Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic Acids.
7. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
8. Demonstration of SEM and TEM.
9. Karyotype analysis, banding patterns.
10. Polytene, lampbrush, B-chromosomes and sex chromosomes.
11. Preparation of Polytene chromosome from *Chironomous* larva/*Drosophila* larva.
12. Silver banding for staining nucleolus-organizing region, where 18S and 28S rDNA are transcribed.
13. Orcein and Feulgen staining of the salivary gland chromosomes of Chironomus and Drosophila.
14. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
15. Any other practical based on theory syllabus.

Suggested readings:

[illegible]amurthy, K.V. (2000). Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, [illegible].

[illegible], ECR. (2001). Encyclopedia of Genetics, F. D. Publication, Chicago, USA.

[illegible] DN. (2000). Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, [illegible]ralia.

[illegible] Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. (VIII Edition). Lippincott Williams and Wilkins, Philadelphia.

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5. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (V Edition).. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertonj, G. P. (2009). The World of the Cell. (VII Ed.). Pearson Benjamin Cummings Publishing, San Francisco.
7. Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York, USA.
8. Harris, N. and Oparka, K.J. (1994). Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford, U.K.
9. Gunning, B.E.S. and Steer, M.W. (1996). Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers. Boston, Massachusetts.
10. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
11. Griffiths, A.J.F. et. al.(2000). An introduction to genetic analysis, W. H. Freeman and Company, New York, USA.
12. Rana, S.V.S., (2012). Biotechniques, theory and practices (Third edition), Rastogi publications, Meerut.
13. Hall, J.L. and Moore, A.L. (1983). Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.
14. Roy, S.C. and De, KK. (1999). Cell Biology. New Central Book Agency (P) Ltd.,Calcutta.
15. Hartl, D. L. (1994). Genetics. Jones and Bartlett Publishers International, USA.
16. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.USA

M. Sc. Biotechnology Previous

Paper II : Biological macromolecules, Enzymology & Biotechniques

Amino acids and peptides:

Classification, chemical reactions and physical properties. Biosynthesis of amino acid (Reductive amination, Transamination, GS-GOGAT system). Protein structure (primary, secondary, tertiary & quaternary), Protein folding, Glyco and lipoproteins -structure and function, Globular, Fibrous proteins, Hydrophobic and hydrophilic interactions, Ramachandran plot, Circular Dichroism, SDS-PAGE, Diagonal Electrophoresis, DNA - protein interactions (Yeast mono hybrid system, Biological importance of proteins.

Proteins: Isolation of proteins, Estimation of proteins by Lowry and Bradford's methods. Thermal denaturation and stability of proteins, Reduction of disulphide bonds of proteins.

Nucleotides: Biosynthesis of purines & pyrimidens by denovo and salvage pathways.

DNA and RNA: Isolation of DNA and RNA, Estimation of DNA and RNA by absorbance method, Melting studies of Calf thymus DNA.

Protein and nucleic acid data bases: Structural comparison at secondary and tertiary levels, Computer aided drug designing. Computational techniques in structural analysis.

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Carbohydrate: Classification and reactions , structure and function of mono, disaccharides and polysaccharides. Methods for compositional analysis. (4) Carbohydrate Analysis : Estimation of glucose by Glucose oxidase (Trinder's reagent), Estimation of reducing sugars by Nelson Somogi's method.

Lipids: Classification, structure, biosynthesis and functions of glycerol phospholipids, sphingolipids and cholesterol.

Secondary metabolites: General introduction and significance, Difference from primary and secondary metabolites (Alkaloids, Flavonoids & Steroids).

Principles of thermodynamics : First and second law, concept of free energy high energy compounds.

Enzymes: classification, nomenclature, Structure: concept of holoenzymes, coenzyme, apoenzyme, isoenzymes and prosthetic groups; Allosteric enzymes.

Effect of temperature, time and substrate concentration on α-amylase activity.

Properties: physiochemical and biological properties, role of enzymes as catalysts; substrate specificity, mechanism of enzyme action (active site, chemical modification) and regulation (Zymogens, Isozymes).

Enzyme Kinetics and regulation: Michalis Menten Equation, Km value. enzyme inhibitors, Kinetics of bi-bi substrate reaction, regulation of enzyme activity, feedback inhibition. Enzyme catalysis in solution, effect of organic solvents on enzyme catalysis, Immobilization of enzymes and its application. Determination of active sites. Functional proteins- structure and drug target (enzyme and receptors). Effects of substrate, temperature, pH and inhibitors on enzyme activity and stability, Enzyme engineering. Importance and applications of enzymes. Industrial aspects of enzymology;

Practical Aspects: Preparation of buffers, Evaluation of PKa's, Enzyme immobilization technique.

Microscopy- SEM, TEM, Confocal microscopy. Staining techniques. Micrometry, measurement of dimensions, counting of cells by haemocytometer. Histochemical techniques-Localization of nucleic acids, proteins, lipids, carbohydrates and enzymes.

Chromatography and Spectroscopy: Paper chromatography, TLC,GC/GLC,HPLC, Ion Exchange chromatography, Affinity chromatography, Adsorption chromatography, Gel Filtration (Size exclusion chromatography), Spectrophotometry, Electrophoresis (Paper, Gel, Immunodiffusion etc.); Spectroscopy, GCMS, NMR.

Suggested Laboratory Exercises:

Separation and Characterization of macromolecules: molecular shape and size; molecular weight by liquid chromatography, electrophoresis and spectroscopy

1. Study of localization metabolites in cells by staining techniques
2. Micrometry- measurement of dimensions.
3. Counting of cells by haemocytometer.
4. Estimation of glucose by Glucose oxidase
5. Estimation of reducing sugars by Nelson Somogi's method
6. Reactions of amino acids, sugars and lipids.

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7. Isolation, purity determination and quantitation of cholesterol,
8. Quantitation of Proteins and Sugars.
9. Estimation of DNA and RNA by chemical means.
10. Analysis of oils-iodine number,saponification value, acid number.
11. UV. Visible and IR Spectroscopy- absorption spectra.
12. Enzyme: Purification and Kinetic analysis.
13. Effect of temperature and substrate concentration on α-amylase activity.
14. Electrophoresis of DNA-linear, circular
15. Hybridoma technology
16. Any other practical based on theory syllabus

Suggested Readings:

1. Voet, D. and Voet, JG. (2013). Biochemistry (4th edition), John Wiley & Sons.
2. Segel, IH. (1976). Biochemical Calculations (2nd ed.), John wiley & sons inc.
3. Voot, D. and Voet, JG. (2004). Biochemistry (4th ed.), J Wiley and Sons.
4. Berg J.M., Tymoczko J.L. and Stryer L (2002), Biochemistry, W.H. Freeman
5. Frefilder, D. (). Physical biochemistry, W.H. Freeman & company.
6. Work, TS. and Work, E. (1980). Laboratory Techniques in Biochemistry and Molecular Biology, online version; *www.sciencedirect.com/science/bookseries/00757535*
7. Rao, CNR. (1999). Understanding Chemistry, Universities press, Hydrabad.
8. Wilson, K. & Goulding, KH. (1986). A Biologist's Guide to principles and Techniques of practical biochemistry, ELBS Edition.
9. Cooper, TG. (1994).Tools of Biochemistry,
10. Malaciński, GM. (2005). Essentials of Molecular Biology, Jones and Barllett publications.
11. Creighton, TE. (1993). Proteins-Structure and Molecular properties, WH freeman and company.
12. Branden, C. and Tooze, J. (1991). Introduction to protein structure, Garland publishing, New York.
13. Kendrew, J. (1994). Encyclopaedia of Molecular Biology, Blackwell scientific publications,oxford.
14. Taford, C. (). Physical chemistry of Macromolecules, John Wiley and Sons.
15. Cantor, CR. and Schimmel, PR. (1080). Biophysical chemistry, WH Freeman.
16. Marie-Claire Bellissent-Funel (ed.) (1992). Protein Structure by Max Perut Perutz. In: Hydration Processes in Biology: Theoretical and Experimental Approaches.
17. Gelvin, S.B. and Schilperoort, R.A. (eds.) (1994). Plant Molecular Biology Manual. 2nd edition, Kluwer Academic Publishers, Dordrecht. The Netherlands.
18. Glick B.R. and Thompson, J.E. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
19. 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.
20. Shaw, C.H. (Ed.) (1988). Plant Molecular Biology: A Practical Approach, IRL Press, Oxford.
21. Rana, S.V.S., 2012. Biotechniques, theory and practices (Third edition), Rastogi publications, Meerut.
22. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
23. Watson, JD., Gilman, M., Witkowski, J and Zoller, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.

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PAPER III: Genetics and Computer applications

Gene Structure and expression : Genetic fine structure, Operon concept, Introns and Exons, cis-trans test, fine structure analysis of eukayotes, introns and their significance, Gene family..

Inheritance and allelism: Mendelian and non- Mendalian inheritance, Gene interaction: Complementary genes (9:7 ratio); Supplementary genes (9:3:4 & 9:6:1 ratios), Epistasis (12:3:1, 13:3 ratios), Duplicate genes (15:1) co-dominance. Extra nuclear inheritance: Cytoplasmic male sterility, inheritance of mitochondrial and chromosomal plant genes; Hardy-Weinberg Law. Multiple alleles and blood groups in man.

Genetic recombination: Homologous and non-homologous recombinations; independent assortment and crossing over; molecular mechanism of recombination, Holiday junction, site-specific recombination, FLP/ FRT and cre / lox recombination, role of Rec A and Rec BCD enzymes and other recombinations.

Chromosome mapping: Linkage map, mapping with genetic markers including RAPD, QTL, construction of molecular maps, restriction mapping- concept and technique, correlation of genetic and physical maps, mapping by using somatic cell hybrids.

Mutation and types of DNA damage: Mutagens and their effects – Physical (Radiations) and Chemical (Base analogues, Intercalating agents, Alkylating agents and others), Types of mutation- Spontaneous and induced mutations, lethal, conditional, biochemical, loss and gain of function, base substitution, frame-shift mutation, germinal verses somatic mutantation, Mutations induced by transposons.

DNA damage & Repair- Direct reversal of damages (Photoreactivation and Dealkylation), Excision Repair mechanisms (NER and BER), Post-replication repair mechanisms (Mismatch repair and Recombination repair), SOS repair. Inherited diseases and defects in DNA repair.

Mutagenesis: Insertional mutagenesis, site-directed mutagenesis, *in vitro* mutagenesis and deletion techniques, Ames test for mutagenesis. Ploidy and their genetic implications.

Structural and numerical alterations in chromosomes : Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Origin, occurrence, production and meiosis of haploids, aneuploids and euploids; origin and production of autopolyploids; chromosome and chromatid segregation, allopolyploids types; genome constitution and analysis. Evolution of major crop plants, induction and characterization of trisomics and monosomics.

Introduction to computer: Characteristics of Computers, Uses of computers, Types and generations of Computers. Basic Computer Organization: Basic components, CPU, ALU, memory hierarchy, registers, Input- output devices (hardware and software) and their functions; User Interface with the Operating System, System Tools. Conceptual understanding of assemblers, compilers, operating systems.

Handling of Data and Statistical Analysis: Brief description, classification and tabulation of data and its graphical representation. Measures of central tendency and dispersion: mean, median, mode, range, standard deviation, variance, idea of two types of errors and level of significance, test of significance (F test, T test, Z test and chi- square Test):. Probability distributions (Binomial, Poisson

and normal); sampling distribution; simple linear regression and correlation. Application of computers in Biostatical problems.

Multimedia: Introduction, Characteristics, Elements, Applications

Information retrieval: LAN, WAN, introduction to internet, WWW. NICNET, ERNET, VSNL, ISDN, E-mail, Publication on worldwide web, on line publishing ventures e.g., Biomed, online international database access. Motif analysis and power point presentation.

General Awareness & Applications: IT Act, System Security (virus/firewall etc.) I-Tax, Reservations, Banking. Proteomics; genomics; metabolomics.

Biological database: primary sequence database (Protein and DNA database), secondary database, composite databases. Sequence alignment and Database searching. Database similarity searching; FASTA, BLAST. Paintise database searching: EMBOSS, multiple sequence alignment; CLUSTAL W, Protein-protein interaction through docking, BTIS, and Network in India. ORF & Gene prediction tools

Suggested Laboratory Exercises:

1. Study of Hardy-Weinberg Law using simulations (seeds).
2. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
3. Working out the effect of mono- and trisomy on plant phenotype.
4. Induction of polyploidy using colchicine,
5. Different applications of Colchicine.
6. Study of variations in plants due to numerical alterations in chromosomes.
7. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
8. Numericals based on inheritance and gene interactions.
9. Flow cytometry and confocal microscopy.
10. Dot-matrix comparison – understanding sliding window – window size (word size) and stringency
11. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
12. Document Preparation.
13. Pairwise alignment and Multiple sequence alignment.
14. Making Patterns and consensus sequence from multiple sequence alignments.
15. Spreadsheet Handling, Working with worksheets, Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.
16. Analysis of data and calculation of standard deviation and variance.
17. Test of significance (F test, T test, Z test and chi- square Test).
18. Searching protein sequence databases with FASTA and BLAST.
19. Compositional analysis of DNA – GC/AT content - codon usage - codon bias.
20. Understanding ORF and gene prediction.
21. Protein structure visualization.
22. Secondary structure prediction online.

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23. Understanding the bioinformatics on human, rice, yeast and *E. coli* genome projects.
24. Protein docking

Suggested Readings:

1. Atherly, AG., Girton, JR. and McDonald, JF. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
2. Burnham, CR. (1962). Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
3. Busch, H. and Rothblum, L. (1982). Volume X. The Cell Nucleus rDNA Part A. Academic Press.
4. Hartl, DL. and Jones, EW. (1998). Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
5. Khush, GS. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.
6. Lewis, R. (1997). Human Genetics: Concepts and Applications (2nd editions). WCB McGraw Hill, USA.
7. Russel, P.J. (1998). Genetics (5th edition). The Benjamin/Cummings Publishing Company INd., USA.
8. Fukui, K. and Nakayama, S. (1996). Plant Chromosomes: laboratory Methods. CRC Press, Boca ratan, Florida.
9. Sharma, AK. and Sharma, A. (1999). Plant Chromosome Analysis, Manipulation and Engineering. Hoarwood Academic Publisher, Australia.
10. Gardner. EJ., Simmons, MJ., Snustad, DP. (2008). Principles of Genetics (VIII ed). John Wiley & Sons.
11. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics (V Edition). John Wiley and Sons Inc. USA.
12. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics (XI Edition). Benjamin Cummings Publishing Company INd., USA.
13. Russell, P. J. (2009). Genetics - A Molecular Approach.(III Edition). Benjamin Cummings Publishing Company INd., USA.
14. Pevsner, J. (2009). Bioinformatics and Functional Genomics (II Edition). John Wiley & Sons.
15. Griffiths, AJF. Wessler, SR., Lewontin, RC. and Carroll, SB. (2008). Introduction to Genetic Analysis (IX Edition). W. H. Freeman & Co.
16. Arora, MP. Gurdarshan and Sandhu, S. (2004). Genetics. Himalaya Pub. House, New Delhi.
17. Rajaraman, V. (2010). **Fundamentals of Computers**, Fourth Edition, PHI.
18. Goel, Anita, (2010). **Computer Fundamentals** Dorling Kindersley (India)
19. Goel, Anita, Computer Fundamentals – Free PDF Downloads

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booksily.net/pdf/computer-fundamentals-anita-goel-2013-unit-1
pu.ibirat.com/.../Computer%20Fundamental%20By%20Goel%20An
www.e-bookspdf.org › Download

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19. Chang, Jeff et al., (2013). Biopython Tutorial and Cookbook - Free Download *biopython.org/DIST/docs/tutorial/Tutorial.html*
20. David W. Mount, (2004). Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press
21. Durbin, RM., Eddy, SR., Krogh, A., Mitchison, G. (2013). Biological Sequence Analysis; Probabilistic Models of Proteins and Nucleic Acids. Cambridge Univ. Press.
22. Baxevanis, A D. and Ouellette, BF Francis. (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (Third Ed). John Wiley and Sons, USA.
23. Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, internet, Bioinformatics books and Journals, Bioinformatics web-portals.
24. Pevsner, J. (2009). Bioinformatics and Functional Genomics (II Edition). John Wiley & Sons.

Note: Use of Open Office/ Star Office is recommended, as they are freely downloadable.

Reference manual for Open Office available at: http://www.openffice.org

Reference manual for Star Office available at: http://www.sun.com/software/staroffice/

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Paper IV: Molecular Biology

Genetic material: The Structures of DNA and RNA / Genetic Material, Types of DNA, Types of genetic material, DNA topology - linking number, topoisomerases; Organization of DNA in Prokaryotes, Viruses, Eukaryotes.

DNA Replication: Genome and its organization; Prokaryotic and eukaryotic DNA replication. Unit of replicon, enzymes involved, mechanisms of DNA replication, origin and replication fork, fidelity of replication, accessory proteins involved in DNA replication.

Antisense and Ribozyme Technology: Molecular mechanism of antisense molecules, Biochemistry of Ribozymes –Hammerhead, hairpin, RNAse P and other ribozymes, applications of antisense and ribozyme technology.

Transcription-Prokaryotic, Eukaryotic transcription, transcriptional factors and machinery, RNA polymerases, Regulatory elements and mechanisms of transcription regulation, formation of initiation complex, transcription activators and repressors, capping, elongation and termination, RNA processing, RNA editing, structure and function of mRNA & snprotein, spliceosome, type III intron, splicing of eukaryotic RNA, polyadenylation, structure and function of mRNA, RNA transport, nuclear export of m- RNA, m-RNA stability, catabolite repression, attenuation and anti-termination.

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Regulation at transcriptional level: Signal transduction- Environmental signals to Cell surface, intracellular communication; Protein DNA interaction, Transcriptional complex and activation of smart gene; Activation of transcription by Gene battery; Processing regulation i.e. splicing in different manner e.g. Troponin gene; Repression of transcription- Gene silencing .

Translation -Prokaryotic and eukaryotic translation, the translation machinery, tRNA structure and function, Genetic code (nuclear and orgenell). Ribosome subunits its molecular structure and function; Formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, aminoacylation of t –RNA, aminoacyl tRNA synthetase, termination of translation, proof-reading; translational inhibitors; Co- and Post- translational modification of proteins.

Regulation at translational level: Activation and Repression of translation through mRNA binding protein, Phosporylation of eukaryotic initiation factors of translation; Repressor protein, Cytoplasmic control of mRNA stability.

Regulation of gene expression in prokaryotes and eukaryotes - Panoply of operon; Spatial (Tubulin gene in plants) & temporal (Globin gene in animals) regulation; Tissue specific gene regulation.

Protein Localization: Synthesis of Secretary and membrane proteins, intracellular protein traffic-import into nucleus, mitochondria, chloroplast and peroxismes, Receptor mediated endocytosis.

Biotechniques of Genetics and Molecular Biology: Genetic recombination Techniques and screening of recombinants, Insertion mutation of a cloned gene, Isolation of plasmids and their curing, Restriction analysis of plasmids to locate position of inserts, Restriction mapping of the plasmid, Cloning of restriction fragment containing neomycin phosphotransferase gene, Expression of β-gal under different promoters, with wild type *E.coli* as control.

Suggested Laboratory Exercises:

1. Preparation of culture medium (LB) for *E.coli (both solid and liquid)* and raise culture of *E.coli*.
2. Isolation of genomic DNA. and its quantification
3. Perform DNA amplification by PCR.
4. Isolation of RNA.
5. Demonstration of antibiotic resistance
6. Metabolic labelling of proteins and immunoprecipitation.
7. Any other practical based on theory syllabus.

Suggested Readings:

1. Sambrook, J., Fritsch, EF. and Maniatis, I. (2000). Molecular Cloning: A Laboratory Manual, Cold Spring harbor Laboratory Press, New York.
2. Dabre, PD. (1988). Introduction to Practical Molecular Biology, John Wiley & sons Ltd.,Yourk.
3. Brown, TA. (Ed.) (1991). Molecular Biology LabFax. Bios Scientific Publishers Ltd, Oxford.
4. Watson, JD., Hopkins, NH., Roberts,JW. Steitz, JA. (). Molecular biology of the Gene (4th Edition).

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5. Darnell, J., Lodish, H. and Baltimore, D. (1994). Molecular Cell biology (2nd Edition). Scientific American Books,USA.
6. Alberts,B., Bray, D., Lewis, J. Raff, M. Roberts, K. and Watson, JD. (1994). Molecular Biology of the Cell (2nd Ed). Garland publishing. Inc., New York.
7. Benjamin Lewin.(1998). Gene VI(6th Edition) Oxford University Press.U.K.
8. Meyers, RA. (Ed.) (1995). Molecular Biology and biotechnology.A comprehensive desk reference. VCH Publishers, Inc., New York.
9. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments (VI Edition). John Wiley & Sons. Inc.
10. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
11. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008). Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.USA
12. Watson, JD. (2013). Molecular Biology of the Gene Plus Mastering Biology with eText (7th Edition). Benjamin Cummings Publication, USA
13. Lodish, H.et al. (2012).Molecular Cell Biology (7th edition). Benjamin Cummings Publication, USA.
14. Glick B.R. and Thompson, J.E. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida
15. 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.
16. Gelvin, S.B. and Schilperoort, R.A. (eds.) (1994). Plant Molecular Biology Manual. 2nd edition, Kluwer Academic Publishers, Dordrecht. The Netherlands.

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Paper V: Microbial Diversity, Physiology & Genetics

History and Development:, Microbial evolution, systematic and taxonomy; primitive organisms and their metabolic strategies and molecular coding; New approaches to bacterial taxonomy classification including ribotyping, Ribosomal RNA sequencing

Prokaryotic and eukaryotic diversity: Nomenclature and Bergey's Manual; Prokaryotic Cells: Structure and Function-Cell wall composition of Gram+ve & -ve bacteria; Cell wall and cell membrane synthesis; Flagella and motility; cell inclusions like endospores, gas vesicales. Bacteria: Purple and green bacterial, budding bacteria, Spirochaetes; Sheathed bacteria, Endospore forming rods and cocci; Mycobacteria; Mycoplasma. Archaea: Archaea as earliest life forms; Halophiles, Methanogens; Hyperthermophilic archaea and Thermoplasma.

Eukarya: Algae, Fungi, Slime molds and Protozoa- General characteristics and types

Pathogenic bacteria of medical importance: Nomenclature and Classification; Gram Positive cocci of Medical Importance - Pneumococcus, Staphylococcus, Micrococcus, Streptococcus; Gram negative cocci - Neisseria, Branhamella; Gram positive bacilli - Coryneform organisms, Actinomyces, Clostridium; Gram negative bacilli - Vibrios, Aeromonas, Haemophilus, Bordetella,

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Enterobacteriaceae, mycobacteria, spirochetes, Chlamydiae, Rickettsiae. Establishment, spread, tissue damage and anti- phagocytic factors.

Microbial Growth: Pure culture technique; Microbial Growth- definition, mathematical expression, growth curve, measurement and yields, Synchronous growth, Continuous, Batch and Fed Batch Culture; Factors affecting growth: temperature, acidity, alkalinity, water availability and oxygen; Culture collection maintenance and preservation.

Microbial genetics : General overview of microbial Genetics; Recombination - transformation, conjugation, transduction; Bacterial genetic map with reference to *E. coli*. Genetic system of yeast and *Neurospora*

Physiology and Metabolic Diversity among Microorganisms: Microbiological principles, physiology, biochemistry. Nutritional classification of microorganisms- chemoautotrophs, chemotheterotrophs and photosnthetic microorganisms. Photosynthesis in microorganisms: Role of Chlorophylls, Carotenoids and phycobilins; Light and Dark Reaction; Chemolithotrophy; Hydrogen, Iron, Nitrate and oxidizing bacteria; Nitrate and sulfate reduction; Nitrogen metabolism; Nitrogen fixation. Hydrocarbon transformation; Syntrophy; Role of anoxic decomposition.

Chemotherapy and Antimicrobial agents: Sulfa drugs; Antibiotics; Pencillin and Cephalosporin; Antibiotics from prokaryotes and eukaryotes; Mode of action; Resistance to antibiotics.

Suggested Laboratory Exercises:

1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms.
3. Isolation of pure cultures of bacteria from soil and water.
4. Growth: Growth curve, Measurement of bacterial population by turbidometry and serial dilution methods.
5. Effect of temperature, pH and carbon and nitrogen source on growth.
6. Microscopic examination of bacteria, yeast and molds.
7. Staining techniques to observe bacterial structure: Simple staining, Gram staining, Negative staining, Acid fast stain, Endospore staining, Capsule staining
8. Study of mutations by Ames test.
9. Biochemical characterization of selected bacterial strains.
10. Isolation and identification of pathogenic fungi from plants.

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1. Isolation and identification of nonpathogenic fungi from soil.
2. Raising fungal pure cultures by hyphal tip culture & single spore culture.
3. Microbiological examination of milk: By Methylene-blue dye reduction test
4. Other practical based on theory syllabus.

Suggested Readings:

1. Pelczar, MJ Jr., Chan, ECS. and Kreig, NR. (2004). Microbiology (5th Ed). Tata McGraw Hill.
2. Maloy, SR., Cronan, JE Jr. and Freifelder, DJ. (1998). Microbial Genetics, Jones and Bartlett Publishers.
3. Benson, HJ. (1999). Microbiological Applications,(A Laboratory Manual in General Microbiology) (7th edition), William C Brown Publishers.
4. Purohit,SS. (2003). Microbiology: Fundamentals and Applications Published by Agrobios, India.
5. Salle, AJ.(1999). Fundamental Principles of Bacteriology, (7th ed.) Tata- McGraw Hill
6. Prescott, LM., (2005). Microbiology, (6th ed.) McGraw-Hill.
7. Kathleen Park Talaro & Arthur Talaro (2002) Foundations in Microbiology International edition. McGraw Hill.
8. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
9. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM.T.Brown Publishers.
10. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
11. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/Benjamin Cummings.
12. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). *General Microbiology*. 5th edition. McMillan.
13. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition. Pearson Education.
14. Vashishta BR and Sinha AK. (2008). *Fungi*. S. Chand and Company Ltd.
15. Black JG. (2008). *Microbiology: Principles and Explorations*. 7th edition. Prentice Hall
16. Srivastava S and Srivastava PS. (2003). *Understanding Bacteria*. Kluwer Academic Publishers, Dordrecht
17. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th

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edition Pearson Education.

18. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology.*

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Paper VI: Pathogenesis, Virology and Immunology

Disease development: Introduction and history, Host parasite relationship- Normal microflora of skin, oral cavity, gastrointestinal tract; entry of pathogens into the host; colonization and factors predisposing to infections. Types of toxins (exotoxins, endotoxins, entrotoxins) and their structures; mode of action (biochemical, physiological); nonspecific and specific defense mechanisms, virulence and pathogenesis.

Microbial Diseases- Infectious disease & transmission; Respiratory infections caused by bacteria and viruses; Tuberculosis; Disease transmitted by animals (rabies), insects (malaria) and ticks (rickettsias). Food and water borne diseases; Emerging and resurgent infectious diseases. Plant diseases caused by microbes.

Viruses: Nomenclature and classification; morphology and ultra-structure; Capsid and their arrangements; Genetics of viruses; distinctive properties of viruses.

Animal and human viruses: Epidemiology, life cycle, pathogenecity and diagnosis. Prevention and treatment of RNA viruses: Enteroviruses, Orthomyxoviruses, Paramyxoviruses and Rhabdoviridae. DNA viruses: Poxviridae, Herpesviridae, Adenoviridiae, Hepadna virus. Viral vaccines, interferons, and antiviral drugs.

Effect of viruses on plants: Symptomatology, histopathology, physiology and pathogenicity. Common viral diseases of plants (TMV, Cauliflower mosaic virus and Potato virus X). Transmission of plant viruses through vectors (insects, nematodes, fungi) and without vectors (contact, seed, pollen transmission). Brief account of diagnostic techniques in plants; infectivity assay of plant viruses, indicator plants, histochemical tests and vector control.

Immunology: Brief history, innate responses, innate and acquired immunity, organization and structure of lymphoid organs. Nature, biology and types of antigens and super antigens. Antibody structure and types; theories of antibody production; Antigen antibody interaction.

Cells of immune system: Lymphocyte (B-cells, T-cells and natural killer cells); Antigen presenting cells (Macrophages, B cells, dendritic cells), killer T cells, also called cytotoxic T lymphocytes (CTLs).

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Hybridoma technology & monoclonal antibodies and its applications, regulation of immune responses- Hypersensitivity, Autoimmunity, Immune response during bacterial (tuberculosis), parasitic (malaria), and viral (HIV) infections, congenital and acquired immune deficiencies.

Immunology techniques: Purification of Immunoglobin from serum, Double diffusion, Generation of antibody in mouse, Conjugation of antibody in mouse, Conjugation of antibody with enzyme, ELISA (i) Capture ELISA,(ii) Direct ELISA , Western blot, Affinity column and purification of antigen, Cell fusion for generation of Hybridoma.

Suggested Laboratory Exercises:

1. Study of various symptoms produced in plants due to virus infection.
2. Study of viral diseases of plants/ animals/ human (Specimen/ photographs)
3. Different type of viruses (Photographs/ sketches).
4. Raising virus free plants through apical meristem culture.
5. Blood film preparation and identification of cells.
6. Immunization, Collection of Serum.
7. Double diffusion and Immuno-electrophoresis.
8. Radial Immuno diffusion.
9. Purification of IgG from serum.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Con-A induced proliferation of thymocytes (by MTT method).
12. ELISA.
13. Immunodiagnostics (demonstration using commercial kits).
14. Any other practical based on theory syllabus.

Suggested Readings:

1. Morag C and Timbury M.C. 1994. Medical virology-X Edition. Churchill Livingstone,London.
2. Dimmock NJ, Primrose SB. 1994. Introduction to Modern Virology,IV Edition,Blackwell Scientific Publications,Oxford.
3. Conrat HF, Kimball PC and Levy JA. 1994. Virology (III Edition), Prentice Hall, Englewood cliff, New jersey. USA.
4. Matews, RE. 1992. Functionals of plant virology, Academic press, San Diego.
5. Topley and Wilson's 1995. Text Book on principles of Bacteriology, virology and Immunology, Edward Arnold, London.
6. Lennetter, 1984. Diagnostic procedures for viral and Rickettsial diseases. American public Health association, NY.
7. William Hayes, 1985. The genetics of Bacteria and their viruses. Blackwell Scientific Publishers, London.
8. Ronald M. Atlas. 1995. Principles of microbiology. Mosby Year Book Inc. Missouri 63146.
9. Kenneth M. Smith, 1996. Plant viruses. Universal Book Stall, New Delhi.
10. Walkey D.G.A.1985. Applied Virology. International Books & Periodicals supply service. New Delhi.
11. Maramarosch Karl, 1992. Plant Deseases of viral, viroid, Mycoplasma & uncertain etiology. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay, Calcutta.

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2. Powar, C.B. and Daginawala, H.F. 2003. General Microbiology Vol. II. Himalaya Publishing House.Mumbai.
3. Biswas, A. Biswas, SK. 2006. An Introduction to Viruses. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Agrios, G.N. 1997. Plant Pathology, Academic Press. NY. USA.
5. Kuby Immunology, (4th Edition) R.A. Goldsby, Thomas J. Kindr Barbara, A. Osbame; (Freeman) & Co. New York.
6. Bloom, BR. Lambert, PH. 2000. Immunology: A short course (4th Edition), John Wiley & Sons
7. Roitt, .M.1998. Essentials of Immunology, ELBS, Blackwell Scientific publishers, London.
8. Gerhardt. P. Murray, R. Ce., Wood W.A., and Kreig N.R.(eds.) 1994. Methods for General and Molecular Bacteriology . American Society for Microbiology, Wasington D.C.
9. Pelczar MJ. Chan ECS. Krieg NR. Microbiology (5th Edition) Tata McGraw Hill, Delhi.
10. Kumar, S. 2012. Textbook of Microbiology, Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.

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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 culture, 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[redacted]tory Manual Cold Spring Harbor Laboratory Press,New York.
2. Glover, DM. and Hames, BD. (1995). DNA Cloning: a practic[redacted] IRL Press Oxford.
3. Kaufman, PB., Wu, W., Kim, D. and Cseke, LJ. (1995). Molec[redacted]ethods in Biology and Medicine CRC Press.Florida.
4. Berger, SL. and Kimmel, AR. (1998). Guide to Molecular Clonin[redacted] Academic press Inc. San Diogo.
5. Gooddol, DV. (1990). Gene Expression Technology Academic Pres[redacted]go,1990.
6. Mickloss, DA. and Greyer, GA. (1990). DNA Science A Firs[redacted]combinant Technology, Cold Spring Harbor Laboratory Press, New York.
7. Primorso, SB. (1994). Molecular Biotechnology (2nd Edn.), Blackw[redacted] 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)

PER XI: Environmental Biotechnology, Biosafety, Ethics and Research Methodology

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

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