

SYLLABUS
M.Sc. (BIOTECHNOLOGY) PART-II
(Semester III & IV)
Session 2015-16 and 2016-17

The course will consist of two semesters in the second year i.e., semester III and IV. In each semester, there shall be four theory papers and two practical papers. In addition, the students shall undertake in-plant training of 4-6 weeks at various industries/institutes/R&D centres, etc. after completion of theory and practical examinations of semester II, which will be evaluated during the semesters III and IV.

Each theory paper shall have 5 hours teaching and 3 practical hours per week. Each theory paper shall be of 100 marks, of which 75 marks shall be allocated to the theory paper set by external examiner. The internal assessment in each paper shall have 25 marks, including a seminar and an assignment of 5 marks each and 5 marks shall be given for the attendance of the student. There shall be two tests of 10 marks each and average of the two tests shall be considered. The seminars will be allotted to all the students from the respective syllabi of theory papers in such a way that each student could be assessed by the teacher of the concerned subject. The awards of internal assessment shall be dispatched by the Head of the department before the commencement of semester examinations.

The subjects and distribution of marks shall be as under:

SEMESTER III

Theory Papers

Paper IX: Enzymology	100 marks
Paper X: Microbial and Food Technology	100 marks
Paper XI: Environmental Biotechnology	100 marks
Paper XII: Commercial Biotechnology	100 marks

Practical Papers

Practical Paper V: Pertaining to Theory Paper IX & X	100 marks
Practical Paper VI: Pertaining to Theory Paper XI & XII	100 marks

SEMESTER IV

Theory Papers

Paper XIII: Tissue & Cell Culture Technology	100 marks
Paper XIV: Research Methodology	100 marks
Paper XV: Computers & Biostatistics	100 marks
Paper XVI: Fundamentals of Bioinformatics	100 marks

Practical Papers

Practical Paper VII: Pertaining to Theory Paper XIII & XIV	100 marks
Practical Paper VIII: Pertaining to Theory Paper XV & XVI	100 marks

Total marks for M.Sc.-II shall be as under:

SEMESTER III

Theory Papers (4)	400 marks
Practical Papers (2)	200 marks
Total	600 marks

SEMESTER IV

Theory Papers (4)	400 marks
Practical Papers (2)	200 marks
Industrial Visits and In-plant Training Seminars Satisfactory/ Unsatisfactory (Fail)	
Total	600 marks
Grand Total (Semester III & Semester IV)	1200 marks

In-plant training seminar and industrial visits shall be evaluated by a board of two teachers and communicated by Head of department before commencement of final examinations.

SEMESTER-III
PAPER IX: ENZYMOLOGY

Maximum Marks: 75
Time Allowed: 3 Hours

Lectures to be delivered: 60
Pass Marks: 35% (Theory and
Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Enzymes: Structure, evolution and its basis.
2. Enzyme action: Specificity, molecular aspects of enzyme action, and examples from different classes of enzyme.
3. Regulation of enzymic action: Activation of enzymes, covalent modification, allosteric interaction, multienzyme complexes.
4. Industrial production of enzymes: Sources of enzymes, criteria for the selection of source for enzyme production, methods of large scale production-solid substrate fermentation and submerged fermentation, factors affecting enzyme production, amylases, cellulases, pectinases, lactases, invertases, lipases, proteases.
5. Immobilization of biocatalysts: Definition, objectives and advantages of immobilization; techniques of immobilization, matrices - types, advantages and limitations.
6. Kinetic characterization: Immobilized enzymes - comparative account of immobilized biocatalysts, concept of co-immobilization.

SECTION-B

7. Biochemical applications: Role of soluble and immobilized enzymes in the synthesis and production of amino acids and chiral compounds; use of enzymes as detergents.
8. Pharmaceuticals: Role of soluble and immobilized enzymes in production of antibiotics, steroids, and other important intermediates of biotechnological industry; role of soluble and immobilized enzymes in diagnosis and treatment of diseases; enzyme therapy.
9. Applications in food industry: Soluble and immobilized enzymes - food production and processing, amylases, pectinases, proteases, lipases, glucoisomerases, naringinase.
10. Analytical applications: Theory and applications of various enzyme electrodes e.g. enzyme sensors, enzyme membranes, biochips/bio-semiconductors.
11. Enzyme engineering: *In vitro* approaches to improve functional efficiency; Recombinant enzymes.
12. Enzymes in organic solvents: Modes of using enzymes, fundamentals and new properties.

RECOMMENDED READING

1. *Fundamentals of Enzymology: The cell and Molecular Biology of Catalytic Proteins* by N.C. Price and L. Stevens, Oxford University, 2000.
2. *Enzymology Lab Fax* by P.C. Engel, Academic Press, 2003.
3. *Enzyme Structure and Function* by A. Fersht, W.H. Freeman and Co., NY, 1999.
4. *Enzymes, Biomass, Food and Feed (Biotechnology 2E, Vol. 9)* by Rehm, Reed and A. Phuler, Wiley-VCH, Berlin, 2001.
5. *Enzyme Kinetics: Principles and Methods* by H. Bisswanger and L. Bubenheim, April 2002.
6. *Industrial Enzymology: The Application of Enzymes in Industry* by T. Godfrey and S. May, McMillan publishers, 2001.
7. *Enzymes in Food Processing* by G.A. Tucker and L.F.J. Woods.
8. *Manual of Industrial Microbiology and Biotechnology* by A.L. Demain and N.A. Soloman, American Society for Microbiology, USA, 2003.
9. *A Textbook of Industrial Microbiology* by W. Cruger and A. Cruger, Sinauer Associates, USA, 2004.
10. *Enzymatic Reactions in Organic Media* by M.N. Gupta, Birkhauser Verlag publication, 2000.
11. *Supramolecular Enzyme Organization Quaternary Structure and Beyond* by Peter Friedrick, Pregamon Press, Oxford, 1994. 3

PAPER X: MICROBIAL AND FOOD TECHNOLOGY

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION – A

1. Microbial transformation: Types of transformation, applications in biotechnology and food technology, steroid transformations.
2. Pharmaceutical products: Fermentative production of antibiotics, penicillins, cephalosporins, erythromycins, vancomycins and streptomycin.
3. Vaccines: Fermentative production of vaccines & recombinant vaccines; edible vaccines.
4. Production of food additives and ingredients: Fermentative production of amino acids - L-glutamic acid and L-aspartic acid.
5. Production of vitamins: Thiamin (B-1), riboflavin (B-2), vitamin (B-12).
6. Microbial polysaccharides: Fermentative production of xanthan gums, dextrans, cyclodextrins and pullulan.

SECTION – B

7. Fermented foods: Production technology of cheese and bread; brief account of Indian fermented foods (*Idli, Vada, Dosa, Papad, Jalebi, Bhatura, Warries, Marchu, Gundruk*).
8. Fermented dairy products and sugar syrups: Production of cultured dairy milk, cultured cream, yoghurt; Sugar syrups - cane syrup, invert syrup, high fructose syrup, maltose syrup.
9. Immobilized whole cell technology in food industry: Brief account in wine, beer & dairy industry.
10. Food preservation: Physical (dehydration, freeze-drying, heat, irradiation) and chemical (antibiotics, organic acids, nitrates and nitrites, sulphites and sulphur dioxide) methods.
11. Waste utilization: Technology for the utilization of waste from dairy, fruit and vegetable processing industries.
12. Food regulations: Brief account on FSSA 2006, FAO, FDA, AGMARK, HACCP, CODEX ALIMENTARIUS.

RECOMMENDED READING

1. *Biotechnology* by R.H. Rehm and G. Reed (Vol. 4, 5, 6 and 7a), Verlag Press, NY, 1982 and 1987.
2. *Biotechnology, Principles and Applications* by J. Higgins, D.J. Bestand and J. Jones, Blackwell Scientific Publications, London, 1985.
3. *Biotechnology: Food Fermentation Technology* by V.K. Joshi and A. Pandey, Educational Publishers and Distributors, New Delhi, 1997.
4. *Comprehensive Biotechnology* by M. Moo Young (Vol. 3 and 4), Pergamon Press, NY, 1985.
5. *Essays in Applied Microbiology* by J.R. Norris and M.H. Richmong, John Wiley and Sons, NY, 1981.
6. *Fundamentals of Biotechnology* by P. Praive, B. Fraust, W. Sitting and D.A. Sukatesh, WCH, Weinheim, 1987.
7. *Microbial Biotechnology, Fundamentals of Applied Microbiology* by A.N. Glazer and H. Nikaido, W.H. Freeman and Co., NY, 1995.
8. *Prescott and Dunn's Industrial Microbiology* by B. Reed, McMillan Publishers Ltd., Connecticut, 1982.
9. *Principles of Fermentation Technology* by P.F. Stanbury, A. Whitaker and J. Hall, Pergamon Press, NY, 1984.
10. *Yeast Biotechnology* by D.R. Berry, I. Russel and G.G. Stewart, Allen and Unwin, Boston, 1987.

PAPER XI: ENVIRONMENTAL BIOTECHNOLOGY

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION – A

1. Introduction to environmental pollution: nature of pollutants, biochemical and physiological effects of pollutants on plants, animals and microbes; types of toxicity; toxicity assessment using biomarkers-enzymatic, microbial, algal, plant and animal systems
2. Environmental applications of biotechnology: bioremediation- *in situ* and *ex situ*, biological deodorization, municipal waste water treatment, biochemistry of degradation of low molecular weight organic compounds, pesticides, and hydrocarbons; microbial leaching, microbial enhanced oil recovery, treatment of industrial wastes- chemical and biological
3. Principles of Treatment: laboratory and equipment, design for containment of biohazards; bioaccumulation of hazardous wastes: kinetics of uptake, factors affecting uptake; stoichiometry and kinetics of waste treatment: Monod's equation for suspended and attached culture systems
4. Microbial transformations of heavy metal ions: metal microbe interactions, molecular mechanisms of heavy metal resistance in microbes, use of natural and engineered microorganisms; bioleaching, biomining and biohydrometallurgy -microbiology, biochemistry and applications, treatment of heavy metal laded industrial effluents
5. Aerobic treatment technologies: Biochemistry, microbiology and operation details of activated sludge (AS), completely mixed conventional activated sludge (CCAS), contact stabilizer (CSAS), step aeration (SAAS), completely mixed (CMAS), extended aeration (EAAS), pure oxygen or high purity oxygen (POAS), tapered aeration (TAAS) systems, aerated lagoons, aerobic and facultative tricking filters and rotating biological contactors
6. Anaerobic waste treatment technologies: Biochemistry, microbiology and operation details of anaerobic decomposition, anaerobic filter reactor, anaerobic contact reactor, fluidized bed reactor, up-flow anaerobic sludge blanket (UASB), anaerobic baffled reactor; factors affecting process operation.

SECTION –B

7. Solid waste treatment methods: sludge characterization and disposal; land based treatment systems, land farming and composting and vermicomposting- PUSA vermicomposting, requirements and preparation of vermicompost, nutrient comparison with ordinary and farmyard manure, Indian scenario of vermicomposting
8. Biogas technology: biogas technology raw materials, biochemistry, microbiology, biogas plant, factors affecting biogas production and its status in India.
9. Treatment of waste air: biological technologies of waste air treatment-bioscrubbers, biotowers and bioventing
10. Biosensors: Definition, advantages and disadvantages of biosensor, immobilization strategies for the construction of biosensors, types of transducers, Development of Biosensors for heavy metal ions, BOD biosensor.
11. Construction of biosensors and kits: specific for pathogens, insecticides and pesticides, immune-biosensors.
12. Protein engineering and construction of generic biosensors: Modification at DNA level, modification of polypeptide chain, Zinc finger, carbonic anhydrase, CAM, CAMBP engineered antibodies and ion channels modifications that alter activity, surface properties, specificity, coenzyme attachment; New enzyme activities.

RECOMMENDED READING

1. *A Text Book of Biotechnology* by R.C. Dubey. S. Chand & Company Ltd., New Delhi, 2002.
2. *Advances in Industrial Waste Water Treatment* by P.K. Goel, Technoscience publications, 1999.
3. *An Introduction to Molecular Ecology*, by T. Beebee and G. Rowe, Oxford University Press, New Delhi, 2004.
4. *Basic Environmental Science* by G.S.P. Iyer, Educational Publishers and Distributors, New Delhi, 1997.
5. *Biotechnological Applications in Environment and Agriculture* by P.K. Goel and G.R. Pathade, ABD Publishers, Jaipur, 2004.
6. *Biotechnology-Applications to Environmental Protection*, by Mo Mera Pandey, Himalaya Publishing House, 1993.
7. *Clean Technology and the Environment* by R.C. Kirkwood and A.J. Longley, Blackie Academy and Professional, 1995
8. *Commercial Biotechnology*, Elsevier Science publishers B.V., Amsterden, The Newdesk, 1984.
9. *Comprehensive Biotechnology* by M. Moo-Young (Vol. 4), Pergamon Press, New York, 1985.
10. *Environmental Biotechnology and Cleaner Bioprocesses* by E.J. Olguin, G. Sanchez and E. Hernandez, Taylor and Francis Inc., 2003.
11. *Environmental Biotechnology* by M.H. Fulekar, I.B.H Publishing Co. Pvt. Ltd, New Delhi, 2005.
12. *Environmental Engineering* by H.S. Peavy, D.R. Rowe and G. Tchobanoglous, Mc Graw Hill International Edition, 1988.
13. *Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil* by J.L. Schnoor, Wiley Interscience Publication Ltd., NY, 1996.
14. *Environmental Molecular Microbiology: Protocols and Applications* by P.A. Rochelle, Horizon Scientific Press, 2001.
15. *Environmental Science and Biotechnology: Theory and Techniques* by A.G. Murugesan and C. Rajakumari, MJP Publishers, Chennai, 2006.
16. *Environmental Science* by W.P. Cunningham and B. Woodworth, WCB/McGraw Saigo Hill, 1999.
17. *Environmental Technology: Basic Concepts and Applications* by I.S. Thakur, I.K. International Publishing House, New Delhi, 2006.
18. *Industrial Water Pollution Control* by W.W. Elbenfields-jr., Mc Graw Hill international Editions, 1998.
19. *Instant Notes in Ecology* by A. Mackenzie, A.S. Ball and S.R. Virdee, Bios Scientific Publishers Ltd., UK, 1999.
20. *Introduction to Environmental Technology* by A.K. Chatterji, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
21. *Methods in Environment Analysis: Water, Soil and Air* by P.K. Gupta, Agrobios, India, 2007.
22. *Microenvironment and Metabolic Compartmentation* by P.A. Sleri and R.W. Estabrook, Academic Press Inc., New Delhi, 1978.
23. *Pesticide Properties in the Environment* by A.G. Hornsky, R.D. Wauchope and A.E. Herner, Springer-Verlag, New York Inc., 1996.
24. *Protein Immobilization: Fundamentals and Applications* by R.F. Taylor, 1991.
25. *Text Book of Environmental Biotechnology* by P.K. Mohapatra, I.K. International Publishing House Pvt. Ltd., New Delhi, 2006.
26. *Toxic Substances in the Environment* by B.M. Francis, Wiley Interscience Publication Ltd., NY, 1994.

PAPER XII: COMMERCIAL BIOTECHNOLOGY

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION – A

1. Scope and status of biotechnology in Punjab and India.
2. Institutions involved in biotechnology development: DBT, PSCST, International Organizations, University- Industry Relationship.
3. Biosafety: Introduction Biohazards, Department of Biotechnology Biosafety Guidelines 1990, IGMORIS, Cartagena Protocol.
4. Intellectual property rights: Intellectual property and its types, WIPO, UPOV, trade secret protection.
5. Patents: Patentability criteria; Prior art; Types of patent applications, patent specification; Patent claims.
6. Patenting system: Patent filing in India; Patent infringement; Patentability criteria for biological processes and products in India, patent cooperation treaty, Budapest treaty, International depository authorities.

SECTION – B

7. Total quality management: Introduction, concept, role and its importance; Contributions of management thinkers in quality management, introduction to six-sigma.
8. Core concepts of TQM: Quality of profit, cost and economics of quality, competitive bench marking.
9. Tools and techniques of TQM: Techniques for analyzing quality process, statistical process control, problem solving tools.
10. International Organization for Standardization (ISO) - About the organization and its functioning, members, relevance of certification.
11. ISO 9000:2008- members and requirements; Introduction to GMP certification.
12. EMS in industry- ISO 14000:2004- members and requirements.

RECOMMENDED READING

1. *Bare Act, Indian Patent Act 1970 Acts & Rules*, Universal Law Pubs. Ltd., 2007.
2. *Bare Act, Indian Patent Act 1970 Acts & Rules*, Universal Law Pubs. Ltd., 2013.
3. *Genetic Patent Law & Strategy* by C. Kankanala, Manupatra Information Solution Pvt. Ltd., 2007.
4. *Guide to Quality Management Systems for the Food Industry* by R. Early, Blackie Academic, NY, 1995.
5. *Guide to Total Quality Management* by R. Early.
6. *Intellectual Property Law* by Davis, Jennifer, Butterworth's, London 2001.
7. *Intellectual Property Rights on Biotechnology* by K.C.Singh, BCIL, New Delhi, 2004.
8. *Intellectual Property: Patents, Trade Marks and Allied Rights* by W.R. Cornish, Universal Law Publishing, Delhi, 2001.
9. ISO 14000:2004- BIS publication
10. ISO 9000:2008- BIS publication
11. *Law of Intellectual Property* by S.R. Myneni, Asia Law House, Hyderabad, 2001.
12. *Patenting Lives: Life Patents, Culture and Development* by J. Gibso, Ashgate Pubs, 2008.
13. *Total Quality in Information Systems and Technology* by J. Woodali.
14. *Total Quality in Research and Development* by G.C. McLauyjin.
15. *Total Quality Management* by Duncan.
16. *Total Quality Management* by F. Baum.

PRACTICAL PAPER V

Pertaining to:

Theory paper IX: Enzymology

Theory paper X: Microbial and Food Technology

Max. Marks: 100

Practical Time: 60 hours

Time: 4 hours

1. Standardization and optimization of immobilization techniques for enzymes and cells.
2. Comparative kinetic characterization of soluble/free and immobilized enzymes/cells.
3. Production of enzymes at laboratory scale - α -amylase, inulinase, aspartase, pectinase etc.
4. Demonstration of activities of soluble and immobilized enzymes - invertase, α -amylase, inulinase, aspartase, pectinases and naringinase.
5. Fabrication of enzyme sensors and demonstrations of their functions.
6. Enzymatic preparation of high fructose syrup and maltose syrup.
7. Utilization of industrial waste for fermented products.
8. Preparation of Indian fermented foods.
9. Microbial production of polysaccharides.
10. Preparation of fermented dairy products.
11. Preservation of food by physical/chemical methods

PRACTICAL PAPER VI

Pertaining to:

Theory paper XI: Environmental Biotechnology

Theory paper XII: Commercial Biotechnology

Max. Marks: 100

Practical Time: 60 hours

Time: 4 hours

1. Separation of pesticides by HPLC method.
2. Determination of heavy metal ions in industrial effluents by Atomic absorption spectrophotometer and spectrophotometric methods.
3. Characterization of industrial effluents for pH, TS, TDS, TSS, alkalinity and hardness parameters.
4. Evaluation of population potential of waste materials as Biochemical Oxygen Demand (BOD).
5. Determination of chemical oxygen demand (COD) in various effluents.
6. Microbiological analysis of waste water.
7. Development of biosensor (enzyme based/ microbe based) for monitoring heavy metal ion/pesticides in the environment.
8. Testing of xenobiotic degradative abilities of microorganisms.
9. Demonstration of methane production from industrial effluents using batch and anaerobic baffled reactors.
10. Biogas production monitoring by gas chromatography.
11. Bioremediation of heavy metal laden (Ni^{+2}) industrial effluent by immobilized cyanobacteria through packed bed reactor.
12. Bioresin for treatment of chromium-laden effluents.
13. A brief about ISO 14000 certified Indian companies.
14. A brief about ISO 22000 certified Indian companies.
15. A brief about ISO 9000 certified Indian companies.
16. An over view of ISO 9000 family of Quality Management Standards.
17. An overview of ISO 14000 family of Environment Management Standards.
18. National Patent Search: Indian Patents
19. Overview of patent databases.
20. Overview of present status of food industries in India.
21. Overview of present status of food industries in Punjab.
22. Patent search exercises on US patents and EPO patents.
23. To demonstrate the development of a small-scale vermicomposting bin for commercialization.
24. To identify the TQM related problems in an organization and to give a possible solution.
25. To study the essential elements of TQM.
26. Use of MS-Office software to sketch a company profile.
27. Internet Survey of Biotechnology Industries of Punjab.

28. Internet Survey of Biotechnology Industries of India
29. Data retrieval from IGMORIS site pertaining to Genetically Modified LMOs.
30. Designs of Biosafety Lab Level I,II, III and IV.

SEMESTER-IV

PAPER XIII: TISSUE AND CELL CULTURE TECHNOLOGY

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and
Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Plant tissue culture: History of plant cell culture, culture media-composition, preparation and development, cellular totipotency, cryopreservation.
2. Callus and cell culture: Isolation of cells, growth of single isolated cells.
3. Suspension culture: Regeneration and maintenance of callus, organogenesis and embryogenesis.
4. Organ culture: Meristem culture, embryo culture and embryo rescue, anther culture, virus free plant production and haploid plant production, production of synthetic seed, micropropagation.
5. Protoplast culture and fusion: Isolation of protoplasts, culture and regeneration; fusion of protoplasts, selection of fusion products of protoplasts; Cybrids.
6. Somaclonal variation, instability and somaclonal variations, plant transformation-*Agrobacterium* mediated and particle gun mediated, secondary plant metabolites and application of plant biotechnology in crop improvement.

SECTION-B

7. Animal cell culture: History, biology of cultured cells, culture media-composition, preparation and development, cell isolation, establishment and evaluation of cell culture, sterilization techniques for ATC lab.
8. Animal cell lines: Establishment, properties and use of cell lines, cultures of tumor cells; Cryopreservation of animal cells.
9. Culture and scale up: Monolayer culture-surface requirements, gas phase requirements, capillary culture units, micro-carrier culture techniques for laboratory and scale up of cultures, suspension culture scale up.
10. Somatic cell fusion: Methods of somatic cell fusion, selection, properties of cell hybrids and their applications.
11. Animal cloning and embryo transfer: Superovulation, *in vitro* fertilization, embryo transfer technology in animals; Concepts and techniques of cloning.
12. Applications: Industrial applications of animal cell culture; Stem cell culture and its applications.

RECOMMENDED READINGS

1. *Plant Tissue Culture and Molecular Biology* by P.S. Srivastava, N.R. Book Distributors, New Delhi, 1998.
2. *Genetic Transformation in Plants* by R. Walden, Open University Press, Buckingham, 1988.
3. *Animal Cell Culture Technology* by M. Buttler, Open University Press, Buckingham, 1987.
4. *Animal Cell Culture* by R.I. Freshney, A.R. Liss Inc., New York, 1989.
5. *Plant Cell Culture* by H.A. Collins, NR Book Distributors, New Delhi, 1998.
6. *Plant Tissue Culture-Theory and Practice* by S.S. Bhojwani and M.K. Razdan, Prentice Elsevier, London, 1983.
7. *Plant Tissue Culture Methods - Applications in Agriculture* by J. Reinart and Y.P.S. Bajaj, Springer - Verlag, Berlin, 1989.
8. *Plant Cell, Tissue and Organ Culture* by J. Reinart and Y.P.S. Bajaj, Narosa Publication House, New Delhi, 1989.
9. *Plant Cell Culture* by A. Stafford and G. Warren, Open University Press, Buckingham, 1990.

10. *Principles of Plant Biotechnology* by H. Maitell, J. Mathew and R.A. Mackee, Blackwell Scientific Publishers, Oxford, 1985. *Plant Cell Culture Technology* by M.M. Yoeman, Blackwell Scientific Publication, Oxford, 1986.
11. *Plant Cell and Tissue Culture A Laboratory Manual* by J. Reinart and M.M. Yoeman, Narosa Publishing House, New Delhi, 1982.

PAPER XIV: RESEARCH METHODOLOGY

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Objectives and types of research: Definition and types of research (Descriptive and analytical research, applied and fundamental research, qualitative and quantitative research, conceptual and empirical research).
2. Research formulation: Defining and formulating research problem and its necessity, selecting the problem, literature review and its importance; Primary and secondary data sources-library (books, journals, periodicals, reference sources, abstracting and indexing sources, reviews, monographs), patents, web (search engines, online libraries, online journals, e-books, e-encyclopedia, institutional websites); Journals and books-standards of research journals (impact factor, ISSN, ISBN, online and print journals, indexed journals, peer reviewed journals), citation index, H-index; Identifying gaps areas from literature review.
3. Research design and methods: Developing the research hypothesis; Research design – basic principles and need, important concepts; Observations and facts, laws and theories, prediction and explanation, induction, deduction; Development of models, developing a research plan, exploration, description, diagnosis, experimentation.
4. Data collection and analysis: Execution of research, observation and collection of data, methods of data collection, primary data, secondary data; Sampling methods, data processing and analysis, statistical tools, hypothesis testing, generalization and interpretation.
5. Documentation: Techniques and importance of documentation; Role of internet, information technology and computers in research and documentation.
6. Reporting and thesis writing: Structure and components of research report, types of report-monographs, review articles, research papers, thesis, books, technical reports and their significance; Different steps in preparation of a written scientific document- layout, structure and language of reports, illustrations and tables, bibliography, references, footnotes.

SECTION-B

7. Presentation of scientific papers: Poster presentations-layout and format; Oral presentation-planning, preparation, use of visual art, importance of effective communication.
8. Application of intellectual property rights: Commercialisation, copyright, royalty, intellectual property rights and patent law; Plagiarism-concept and authentication of originality of research; Citation and acknowledgement; Reproducibility and accountability.
9. Bioethics: Environmental impacts; Clinical and animal ethical issues and committees.
10. Cost analysis of project: Cost incurred on raw materials, different testing procedures, cost of instrumentation, downstream processing cost (wherever required); Cost of clinical trials.
11. Research grants: International funding agencies; Government and private bodies.
12. Industry-institute interactions: Industrial projects and their feasibility reports; Case studies.

RECOMMENDED READING

1. *An Introduction to Research Methodology* by B.L. Garg, R. Karadia, F. Agarwal and U.K. Agarwal, RBSA Publishers, 2002.
2. *Research Methodology* by S.C. Sinha and A.K. Dhiman, Ess Ess Publications, 2002.
3. *Research Methods: The Concise Knowledge Base* by W.M.K. Tronchin, Atomic Dog Publishing, 2005.
4. *Research Methodology* by R. Panneerselvam, Prentice Hall of India, New Delhi, 2004.
5. *Research Methodology: Methods and Techniques* by C.R. Kothari, New Age International Publishers, New Delhi, 2004.
6. *Research Methodology in Management: Theory and Case Studies* by P.P. Arya and Y. Pal, Deep and Deep Publishers Pvt. Ltd., New Delhi, 2001.
7. *Manual for the Preparation of Industrial Feasibility Studies* by W. Behrens, T.M. Hawranek, United Nations Industrial Development Organization, Vienna, 1991.
8. *Manual for Evaluation of Industrial Projects*, prepared jointly by United Nations Industrial Development Organization and Industrial Development Centre for Arab States.
9. *Thesis and Assignment* by J. Andreson, John Wiley and Sons, 1998.
10. *Preparing for Publication: A Style Book for Authors, Editors, Compilers and Typists*, King Edward Hospital, London.
11. *How to Write and Publish a Scientific Paper* by R.A. Day, Cambridge University Press, UK, 1994.
12. *Research Methods in Biological Sciences* by S. Palanichamy and M. Shanmugavelu, Palani Paramount Publications, Tamil Nadu, 1997.

PAPER XV: COMPUTERS AND BIOSTATISTICS

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Fundamentals of computers: Definition, history and generation of computers, computer organization, memory, input and output devices; Data Representation - binary representation of integers and real numbers.
2. Types of computers and types of processing: Batch, real-time, online, offline, system handling, system commands and utilities.
3. File formats and directory structure; Data organization on a computer; Creating and editing graphic objects and charts, sorting data, filtering etc.; Operating systems - Linux, Windows.
4. Computer networking: Networking topologies, networking protocols - TCP/IP, ftp, http, internet and intranet, Networking gadgets (Router, Switch); Network security.
5. Web browser, e-mail, applications and utilities of windows, browsers, search engines.
6. Programming language C: Character set, identifiers and keywords data types, operator and expression control statements, switch break, continue statements, function arrays, pointers.

SECTION-B

7. Statistics: Definition, scope and applications of statistics in biological research and data analysis.
8. Measures of central tendency: Mean, median and mode; Measures of dispersion; Coefficient of variance; Skewness & kurtosis - concept and measures.
9. Correlation analysis: Simple, partial & multiple; Regression analysis - concept & measures, linear regression.
10. Elementary probability theory: Concepts, definitions and problems; Applications of probability and standard distribution.

11. Probability distributions: Binomial, poisson and normal distributions; Estimation, standard error and confidence interval, goodness of fit, etc.
12. Testing of hypothesis: Concept, types of hypothesis, significance level, degrees of freedom, errors in hypothesis testing, procedure of testing hypothesis; Statistical tests - Chi-square test, t-test, F-test, ANOVA – 1 way and 2 way

RECOMMENDED READING

1. *Introduction to Computers* by A. Leon and M. Leon, Vikas Publishing House, 1999.
2. *Fundamentals of Computers* by V. Rajaraman, Prentice Hall India Pvt. Ltd., 2003.
3. *Computer Architecture and Organizations* by J.P. Hayes, Mc Graw Hill, 1998.
4. *Computer Networks* by A.S. Tanenbaum, Prentice Hall Publs, 2003.
5. *Introductory Statistics* by P.S. Mann, Wiley, 2006.
6. *Advanced Biology Statistics* by A. Edmondson and D. Druce, Oxford University Press, 1996.
7. *Biostatistics : A foundation for Analysis in Health Sciences* by W. Danial, John Wiley and Sons Inc, 2004.
8. *Statistical Methods in Biology* by Norman T.J. Bailey, Cambridge Press, 1995.
9. *Statistical Bioinformatics* by S.K. Mathur, Academic Press, 2010.
10. *Statistics: Concepts and Applications* by P. Nabendu and S. Sahadeb, Prentice Hall Publs, 2005.

PAPER XVI: FUNDAMENTALS OF BIOINFORMATICS

Maximum Marks: 75

Time Allowed: 3 Hours

Lectures to be delivered: 60

Pass Marks: 35% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.
2. The use of scientific calculators is allowed.

SECTION – A

1. Bioinformatics: Definition, applications in scientific research, present bioinformatics scenario in India; Open access computational resources related to Life Sciences viz., NCBI, EBI, EXPASY.
2. Databases, datamining and datamining tools: Characteristics and categories of biological databases, primary, secondary and composite databases, navigating databases; Datamining and datamining tools, nucleic acid and protein sequence analysis.
3. Information retrieval systems and data submission tools: Entrez, SRS; BankIt, Sequin, WebIn.
4. Nucleotide sequence databases: Composition, organization and structure of data entries, INSDC, Genbank, EMBL, DDBL, REBASE, dedicated genome sequence databases (*E. coli*, Human).
5. Primary and secondary protein databases: Composition, organization and structure of data entries, IPSDC, Swiss-Prot, TrEMBL, PIR, UniProt, PDB, CATH, SCOP, PROSITE, Pfam.
6. Composite and specialized databases: composition and organization of OWL, BIOSILICO; Diseases database (OMIM), literature databases (PMC), metabolic pathways (KEGG), enzymes (BRENDA).

SECTION – B

7. Substitution matrices and alignment algorithms: Definition, dynamic programming, sequence comparison algorithms, dot plots; Substitution matrices algorithms - PAM and BLOSUM; Sequence alignment algorithms - pairwise comparison, global sequence alignment algorithm (Needleman Wunsch algorithm), local sequence alignment algorithm (Smith Waterman algorithm), Semiglobal algorithm.
8. Nucleic acid sequence comparison and analysis: Basic concepts of pairwise sequence alignment - types and applications of BLAST and FASTA; Statistical significance of scores; ORF and restriction analysis, sequence translation.

9. Protein sequence comparison and analysis: Pairwise and multiple alignment, peptide cleavage analysis, prediction of transmembrane proteins, *in silico* analysis of protein modifications, reverse translation, protein domains and family classification.
10. Overview of resources for genome analysis: Overview of web resources for genome information and analysis, functional genomics tools, overview of gene identification methods.
11. Protein classification and structure prediction: Protein classification, prediction of protein secondary structure - Chow-Fasman/GOR method; Prediction of protein 3D structure - structural profile method, contact potential method; Viewing protein structures, 2D modeling - RASMOL, MOLMOL; 3D modeling - DeepView (SwissPDB viewer).
12. Phylogenetic analysis: Multiple sequence alignment tools - clustalW; Phylogenetic analysis and methods - overview of Maximum Parsimony method, Distance methods - UPGMA, Neighbor-joining method; Maximum Likelihood approach, distance scores; Tree confidence; Analysis tools – Phylip.

RECOMMENDED READING

1. *Bioinformatics: Sequence and Genome Analysis* by D.W. Mount, Cold Spring Harbor Press, 2001.
2. *Introduction to Bioinformatics* by T.K Attwood and D.J. Perry-Smith, Pearson Education Ltd., 1999.
3. *Bioinformatics: Sequence, Structure and Databanks* by D. Higgins and W. Taylor, Oxford University Press, 2000.
4. *Introduction to Bioinformatics* by A.M. Lesk, Oxford University Press, 2005.
5. *Practical Bioinformatics* by J.M. Bujnieki, Springer-Verlag Berlin, 2004.
6. *Bioinformatics and Molecular Evaluation* by P.G. Higgs, Blackwell Publishing Company, 2005.
7. *Algorithms in Bioinformatics* by G. Benson and R. Page, Springer-Verlag, Germany, 2004.
8. *Bioinformatics Basics: Applications in Biological Science & Medicine* by L.K. Buehler and H.H. Rashidi, Taylor and Francis Group, 2005.
9. *Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids* by Durbin *et al.*, Cambridge University Press, 2007.
10. *Proteins: Structures and Molecular Properties* by T.E. Creighton, W.H. Freeman, 1992.
11. *Fundamental Concepts of Bioinformatics* by D.E. Krane and M.L. Raymer, Pearson Education Inc., 2003.
12. *Structural Bioinformatics* by P.E. Bourne and H. Weissig, Wiley-Blackwell Publishers, 2003.
13. *Methods in Molecular Biology* by S. Misener and S.A. Krawetz, volume 132, Bioinformatics: Methods and Protocols, Humana Press Inc., 2000.
14. *Bioinformatics: Databases, Tools and Algorithms* by O. Bosu and S.K. Thukral, Oxford University Press, 2007.
15. *Bioinformatics Methods and Applications-Genomics, Proteomics and Drug Discovery* by S.C. Rastogi, N. Mendiratta and P. Rastogi, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

Practical Paper VII

Pertaining to:

Theory paper XIII: Tissue and Cell Culture Technology

Theory paper XIV: Research Methodology

Max. Marks: 100

Practical time: 60 Hours

Time: 4 hours

1. Lymphocyte and monolayer culture technique, viability testing and subculturing.
2. Animal cell quantitation.
3. Growth curve of mammalian cell line in culture and determination of cell doubling time.
4. Orientation to a tissue culture facility.
5. Preparation of medium.
6. Callus initiation using an explant.
7. Callus subculturing from an established callus.
8. Micropropagation of provided plant material.
9. Introduction to hardening and biological hardening.
10. Designing a research problem.
11. Oral/poster presentation of a research article.

12. Writing of a scientific document.
13. Searching online sources of literature.
14. Testing of plagiarism.
15. List of funding agencies for procuring research grants.
16. Preparing a research proposal.

Practical Paper VIII

Pertaining to:

Theory paper XV: Computers & Biostatistics

Theory paper XVI: Fundamentals of Bioinformatics

Max. Marks: 100

Practical time: 60 Hours

Time: 4 hours

1. Hands-On experience and regular usage: Windows, Internet, Unix (LINUX)
2. Search comparisons on different search engines
3. Hands-on experience on downloading and uploading using ftp
4. Basic Unix commands
5. Hands-On Word Processing, Spreadsheet Applications
6. Creating database and Database Management
7. Hands-On experience tables and graphs
8. Presentation design using wizards, Inserting graphs, pictures & charts Action buttons, Transitions etc.
9. Introduction and principles of statistical sampling from a population.
10. Frequency distributions and associated statistical measures.
11. Probability measures and probability distributions and Random variable.
12. Correlation, and regression analysis,
13. Hypothesis testing: T, F, Chi-square distribution and tests.
14. Analysis of variance and design of experiment CRD etc.
15. Accession of molecular databases. ENTREZ, SRS.
16. Flat file format of GENBANK and EMBL.
17. Describe databases that can be used to access text information about human diseases.
18. Compare the use of Entrez and ExPasy to retrieve information about a protein sequence.
19. Perform pairwise alignments of the proteins using PAM 30, PAM 70 and PAM 250 matrices.
20. Use of windows and Linux for protein softwares.
21. Compare sequence information from BLAST, PSI-BLAST, PHI-BLAST etc.
22. Microarray/chip analysis: Normalization of gene expression data.
23. Creation of molecules and calculation of energy minimization, torsion angles, band distance, bond angle, Ramachandran plot.
24. Prediction of secondary structure.
25. Perform molecular modeling of given protein structure (3D) database using various softwares.
26. Molecular docking: Download protein sequences and perform docking of a substrate /inhibitor.
27. Glucocorticoid receptors/ zinc fingers binding to DNA.
28. Identifying the ORF using EMBOSS.
29. Open access computational and bibliographic resources related to Life Sciences viz. NCBI, EBI, EXPASY
30. Keyword-based and advanced searches using tools like ENTREZ and SRS
31. Formats, querying and retrieval from GenBank, EMBL, DDBJ, REBASE
32. Formats, querying and retrieval from Swiss-Prot, TrEMBL, PIR-PSD, UniProt-KB; PDB; CATH, SCOP, Pfam, PROSITE
33. Formats, querying and retrieval from OWL, BIOSILICO; diseases database (OMIM), literature databases (PMC), metabolic pathways (KEGG), enzymes (BRENDA)
34. Genomes of model organisms (*E. coli*, Human)
35. Nucleic acid sequence comparison and analysis: types and applications of BLAST and FASTA; multiple sequence alignment: clustalW; statistical significance of scores; ORF and restriction analysis, sequence translation, gene prediction using GENSCAN, GRAIL
36. Protein sequence comparison and analysis: pairwise and multiple alignment, peptide cleavage analysis, prediction of transmembrane proteins, *in silico* analysis of protein modifications, reverse translation
37. viewing protein structures and 2D modeling: RASMOL, MOLMOL
38. 3D modeling and structure prediction: DeepView (SwissPDB viewer)

39. Phylogenetic analysis: Phylip