

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

PUNJABI UNIVERSITY, PATIALA

(Established under Punjab Act No. 35 of 1961)

Faculty of Life Sciences

Syllabi

for

**M.Sc. (Hons.) Biotechnology
(Choice Based Credit System)**

Program Code: BTHM2PUP

3rd & 4th Semester

Sessions: 2021-22 and 2022-23

SEMESTER-III

Paper Code:	BTHM2101T - ENZYMOLOGY & ENZYME TECHNOLOGY
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

This course provides theory and knowledge relevant to enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms and enzyme kinetics. Techniques employed in enzyme purification and characterization is also emphasized in this course. The applications of enzymes in food and pharmaceutical industries, and diagnostics would be deliberated.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

- Enzymes:** Structure (folded conformations, active site geometry and 3D forms), evolution (convergent and divergent) and its basis.
- Enzyme action:** Specificity, molecular aspects of enzyme action (theories and kinetics), and examples from different classes of enzyme.
- Regulation of enzyme action:** Activation of enzymes, covalent modification, allosteric interaction, multienzyme complexes.
- 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.
- Immobilization of biocatalysts:** Definition, objectives and advantages of immobilization; techniques of immobilization, matrices - types, advantages and limitations; Kinetic characterization of immobilized biocatalysts; concept of co-immobilization.
- Nanobiotechnology:** Functionalization of enzymes, types of nanomaterials, mode of interaction and application in food, bioenergy and pharma sector.

SECTION-B

- Biochemical applications:** Role of enzymes in the synthesis and production of amino acids and chiral compounds.
- Biomedical applications:** Enzymes in production of antibiotics; therapeutic enzymes; enzymes in disease diagnosis.
- Applications in food industry:** Application of enzymes in fruit and vegetable processing, dairy industry, beverage industry and meat industry.
- Analytical applications:** Theory and applications of enzyme electrodes e.g. enzyme sensors, enzyme membranes, biochips/bio-semiconductors.
- Enzyme engineering:** *In vitro* approaches to improve functional efficiency; Recombinant enzymes: Overexpression and applications.
- Enzymes in organic solvents/Ionic liquids:** Modes of using enzymes, fundamentals, advantages and challenges.

RECOMMENDED READINGS

- Fundamentals of Enzymology: The cell and Molecular Biology of Catalytic Proteins* by N.C. Price and L. Stevens, Oxford University (2000).
- Enzymology Lab Fax* by P.C. Engel, Academic Press (2003).
- Enzyme Structure and Function* by A. Fersht, W.H. Freeman and Co., NY (1999).

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

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, 3rd edition, Wiley, USA (2017).
6. *Industrial Enzymology: The Application of Enzymes in Industry* by T. Godfrey and S. May, McMillan publishers (2001).
7. *Enzyme Technology* by M.F. Chaplin and C. Bucke, Cambridge University Press, NY (1990).
8. *Enzymes in Food Processing* by G.A. Tucker and L.F.J. Woods.
9. *Principles of Enzyme Technology* by M.Y. Khan & F. Khan, PHI Learning Pvt. Ltd., India (2015).

Paper Code:	BTHM2102T - FOOD BIOTECHNOLOGY
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

The course includes application of microbes for processing and preservation of food. The role of microorganisms in important food fermentations is included. The course also introduces the principle of utilization of food industry waste and regulation on the use of microbes in food industry.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION – A

1. **Microorganisms for food and feed:** Algal, bacterial, fungal and yeast biomass as single cell protein; Solid-state fermentations and submerged fermentation technologies for the production of SCP.
2. **Baker's yeast production and bread making:** Morphology and physiology, production, handling and harvesting of baker's yeast; Production technology of bread.
3. **Probiotic, prebiotic and functional foods:** Concepts and applications in food; Functional foods (oat products, milk and dairy products, sea food products); Biopreservatives - A brief account.
4. **Production of alcoholic beverages:** Raw materials, culture, fermentation technology and post fermentation processing of beer, wine, whiskey, vodka, rum and brandy.
5. **Organic acids:** Fermentative production and applications of citric acid, lactic acid and acetic acid.
6. **Fermented meat and sausages:** A brief account on microbiological changes and production process.

SECTION – B

7. **Indian fermented foods:** Brief account of fermented foods (*Vada, Dosa, Warries, Marchu, Gundruk, Kimchi, Koji, Tempeh, Sauerkraut*, Soya sauce). Fermented dairy products and Indian fermented foods, Production of cheese, cultured dairy milk, cultured cream, yoghurt and kefir.
8. **Sugar syrups:** Glucose syrup, invert syrup, high fructose syrup, maltose syrup.
9. **Microbial colours & flavours and biopreservatives:** Current status and future perspectives.
10. **Immobilized whole cell technology in food industry:** Brief account in wine, beer & dairy industry.
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 READINGS

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. Best and J. Jones, Blackwell Scientific Publications, London (1985).

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

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. Richmond, John Wiley and Sons, NY (1981).
6. *Fundamentals of Biotechnology* by P. Praive, B. Fraust, W. Sitting and D.A. Sukatesh, VCH, Weinheim (1987).
7. *Microbial Biotechnology, Fundamentals of Applied Microbiology* by A.N. Glazer and, H. Nikaido, Cambridge University Press, UK (2012).
8. *Prescott and Dunn's Industrial Microbiology* by G. Reed, CBS Publishers & Distributors, India (2004).
9. *Principles of Fermentation Technology* by P.F. Stanbury, A. Whitaker and J. Hall, 3rd edition, Butterworth-Heinemann, UK (2016).
10. *Yeast Biotechnology* by D.R. Berry, I. Russel and G.G. Stewart, Allen and Unwin, Boston (1987).
11. *Food Biotechnology: Principles and Practices* by V.K. Joshi and R.S. Singh, IK International Publishers Pvt. Ltd., New Delhi (2012).
12. *Handbook of Enology: Principles and Practices* by V.K. Joshi, Asiatech Publishers Inc., New Delhi (2011).
13. *Biotechnology: Food Fermentation Microbiology, biochemistry and Technology* by V.K. Joshi & A.K. Pandey, Asiatech Publishers Inc., New Delhi (2009).
14. *Food Fermentation Biotechnology* by A.K. Pandey, C.R. Soccol and C. Larroche, Asiatech Publishers Inc., New Delhi (2011).

Paper Code:	BTHM2103T - ADVANCES IN ENVIRONMENTAL BIOTECHNOLOGY
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

The main objective of this paper is to provide basic understanding of the ecology of our environment. Reclaiming organically polluted water, air and soil by application of conventional treatment technologies supplemented with native and genetically modified microbes to degrade industrial waste containing recalcitrant compounds, use of animal waste as fertilizer, recycling of microbial protein as an animal feed and removal of heavy metals found in sewage sludges, recovery of oils and minerals of commercial interest are integral components of this interesting area.

INSTRUCTIONS FOR THE PAPER-SETTER

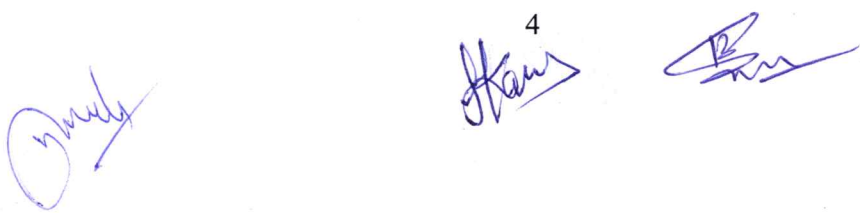
The question paper will consist of three sections A, B and C. Section-A and B will have four questions from the respective sections of the syllabus and carry 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION – A

1. **Environmental pollution:** Effects and bioassays for analysis of pollutants: Introduction to environment and environmental pollution, classification of pollutants, biochemical and physiological effects of pollutants on plants, animals and microbes; types of toxicity, biological indicators of pollution: enzymatic, microbial, algal, plant and animal systems
2. **Waste water treatment processes:** Primary, secondary and tertiary treatment of municipal wastewater: theory and applications: physical treatment, chemical treatment, precipitation: hot and cold soda lime process, disinfection: chlorination, ozonization, UV treatment, demineralization-ion exchange by synthetic resins and zeolites, reverse osmosis, filtration; advanced wastewater treatment: nutrient removal- nitrogen and phosphorus removal
3. **Engineered systems for aerobic wastewater treatment and disposal:** Primary treatment; secondary treatment: suspended culture system-activated sludge (completely mixed and plug flow reactors, process variations), ponds and lagoons, attached culture system-trickling filters, biotowers and rotating biological contactors; mechanism of aerobic biodegradation; factors affecting process operation; derivation of Monod's equation for suspended and attached culture systems



4. **Anaerobic technologies for waste treatment:** Anaerobic decomposition, anaerobic filter reactor, anaerobic contact reactor, fluidized bed reactor, up-flow anaerobic sludge blanket, anaerobic baffled reactor, mechanism of anaerobic degradation, factors affecting process operation; biogas generation-raw materials, biochemistry and microbiology, factors affecting biogas production and its status in India
5. **Treatment of waste air:** Removal of particulate and gaseous contaminants; biological technologies of waste air treatment, biological deodorization: bioscrubbers, biotowers, bioventing
6. **Environmental applications of biotechnology:** Microbial enhanced oil recovery; biosurfactants and biopolymers for MEOR and desulfurization of crude oil, treatment of wastewater of brewery, pharmaceutical, textile dyeing, metal processing, petrochemical, pulp and paper industry; role of natural/stimulated, dead/spent microbial cultures, GMOs and mushrooms in biological degradation processes, phytoremediation

SECTION – B

7. **Solid waste management:** Sludge treatment and disposal: characteristics, thickening, digestion and disposal; land based treatment systems, landfilling, deep well injection, composting and vermicomposting- PUSA vermicomposting, requirements and preparation of vermicompost, nutrient comparison with ordinary and farmyard manure, Indian scenario of vermicomposting; treatment of hazardous and medical waste
8. **Biomining and biohydrometallurgy:** Heavy metal tolerance, metal-microbe interactions, genetic aspects of heavy metal resistance; biomining: mechanism of heavy metal ion deposition; biohydrometallurgy and bioleaching of metals (copper and uranium)
9. **Bioaccumulation:** Bioremediation-*in situ* and *ex situ*, bioaugmentation; characteristics and types of xenobiotics, relationship of bioaccumulation with chemical structure, bioaccumulation of toxicants: uptake kinetics, factors affecting bioaccumulation.
10. **Bioremediation of pesticide:** Metabolic pathways and enzymes for bioremediation of organo chlorinated, organo phosphorous and carbamate pesticides; Biotechnological applications of microbes for pesticide waste disposal.
11. **Biosensors:** Biosensors in environmental monitoring, Applications of biosensors in environmental biotechnology - Urea biosensor to check milk adulteration; Heavy metal ions biosensors; Pesticide biosensors; Nanobiosensors.
12. **Pathogen and BOD biosensors:** SPR, potentiometric and amperometric pathogen biosensors and comparison with conventional methods; BOD biosensors - Principle of DO probe, bacterial and yeast BOD biosensors.

RECOMMENDED READINGS

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. Beebe 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 M.M. 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., Amsterdam, The Newdesk (1984).
9. *Comprehensive Biotechnology* by M. Moo-Young (Vol. 4), Pergamon Press, New York (1985).
10. *Environmental Biotechnology* (Industrial pollution management Edition) by S.N. Jogdand, Third Revised Edition (2006).
11. *Environmental Biotechnology and Cleaner Bioprocesses* by E.J. Olguin, G. Sanchez and E. Hernandez, Taylor and Francis Inc. (2003).
12. *Environmental Biotechnology, Basic concepts and Application* by I.S. Thakur (2006).
13. *Environmental Biotechnology* by M.H. Fulekar, I.B.H Publishing Co. Pvt. Ltd, New Delhi (2005).
14. *Environmental Engineering* by H.S. Peavy, D.R. Rowe and G. Tchobanoglous, Mc Graw Hill International Edition (1988).
15. *Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil* by J.L. Schnoor, Wiley Interscience Publication Ltd., NY (1996).

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

16. *Environmental Molecular Microbiology: Protocols and Applications* by P.A. Rochelle, Horizon Scientific Press (2001).
17. *Environmental Science and Biotechnology: Theory and Techniques* by A.G. Murugesan and C. Rajakumari, MJP Publishers, Chennai (2006).
18. *Environmental Science* by W.P. Cunningham and B. Woodworth, WCB/McGraw Saigo Hill (1999).
19. *Industrial Water Pollution Control*, W.W. Elbenfields-jr., Mc Graw Hill International Editions (1998).
20. *Instant Notes in Ecology* by A. Mackenzie, A.S. Ball and S.R. Virdee, Bios Scientific Publishers Ltd., UK (1999).
21. *Introduction to Environmental Technology* by A.K. Chatterji, Prentice Hall of India Pvt. Ltd., New Delhi (2002).
22. *Methods in Environment Analysis: Water, Soil and Air* by P.K. Gupta, Agrobios, India (2007).
23. *Microenvironment and Metabolic Compartmentation* by P.A. Sreri and R.W. Estabrook, Academic Press Inc., New Delhi (1978).
24. *Pesticide Properties in the Environment* by A.G. Hornsky, R.D. Wauchope and A.E. Herner, Springer-Verlag, New York Inc. (1996).
25. *Popular Biotechnology Lecture Series Focus: Bioremediation* by Division of Biotechnology, PSCST (2013).
26. *Protein Immobilization: Fundamentals and Applications* by R.F. Taylor (1991).
27. *Text Book of Environmental Biotechnology* by P.K. Mohapatra, I.K. International Publishing House Pvt. Ltd., New Delhi (2006).
28. *Toxic Substances in the Environment* by B.M. Francis, Wiley Interscience Publication Ltd., NY (1994).

Paper Code:	BTHM2104T –INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY & ENTREPRENEURSHIP
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

This course at the beginning of the second year of Post Graduation begins by introducing the scope of existing Indian and International Biotechnology Industries. Students are given the perspective of the role of Governments and other agencies in specifically promoting Biotechnology Industry. The students are familiarized with various aspects of University Industry interaction and its scope for their skill development. Students are exposed to the regulatory aspect of new Biotechnological interventions in form of Biosafety guidelines and international treaty concerning Biodiversity. The course will cover the basic concepts of entrepreneurship and legal issues related with biotechnology. This course will provide a basic knowledge about national and international intellectual property regulations. This course will also help to develop basic understanding about total quality management, ISO and biosafety issues. The concepts covered under theory course will be complimented by hands on training sessions to provide them first-hand experience on patent search, ISO standards etc.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. **Intellectual Property Rights:** Intellectual property, types and related Indian legislations; WIPO, international conventions: TRIPs agreement, PCT, Paris convention, Budapest treaty; trade secret protection.
2. **Patents:** Patentable subject matter; patentability criteria: novelty, inventiveness and industrial application; prior art; provisional and complete specifications; patent claims, preparation and preservation of invention records.
3. **Patenting systems:** Types of patent applications, national (India) and international patent filing, patent infringement; patentability of biological processes and products in India; Patent search: databases.

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

4. **International Organization for Standardization (ISO):** About the organization and its functioning, members, relevance of certification.
5. **ISO, GMPs, GLPs Standards:** ISO 9000, ISO 14000 -members and requirements. Standards for Good Manufacturing Practices (GMPs,) and Good Laboratory Practices (GLPs).
6. **Biosafety:** Biohazards, Biosafety Guidelines for recombinant DNA research, biocontainment and foods from genetically engineered plants (Department of Biotechnology, Govt. Of India), Institutional Biosafety Committees, Cartagena protocol.

SECTION-B

7. **Total Quality Management:** Introduction, concept, role and its importance; cost and economics of quality, SWOT analysis.
8. **Tools and techniques of TQM:** Techniques for analyzing quality process, statistical process control, problem solving tools, bench marking and six-sigma.
9. **Entrepreneurship:** Entrepreneurial characteristics. Proprietorship and partnerships, types of partnerships. MSME: classification and clusters.
10. **Business Plan Preparation:** Market analysis, technical analysis, financial analysis. Financial viability assessment: forecasts, projections, ratios, ROI.
11. **Start ups:** Ideation, proof-of-concept, DPR, product life cycle, the role of technology business incubators, SIDBI, NABARD.
12. **Academia-industry interactions:** Product/process development initiatives of Govt: DBT, DST, MoFPI, BIRAC, Technology transfers-process and challenges, Bayh Dole Act.

RECOMMENDED READINGS

1. *Bare Act, Indian Patent Act 1970 Acts & Rules*, Universal Law Pubs. Ltd. (2013).
2. *Biotech Innovations and Fundamental Rights* by R. Bin, S. Lorenzon and N. Lucchi, Springer (2012).
3. *Entrepreneurial Development* by S.S. Khanks, S. Chand and Company, New Delhi (1999).
4. *Entrepreneurship* by T.W. Zimmer and N.M. Scarborough, Prentice Hall, New Jersey, USA (1996).
5. *Entrepreneurship Strategies and Resources* by M.J. Dollinger, Prentice Hall, Upper Saddle River, USA (1999).
6. *Genetic Patent Law & Strategy* by C. Kankanala, Manupatra Information Solution Pvt. Ltd. (2007).
7. *Globalising Intellectual Property Rights: The TRIPS Agreement* by D. Matthews, Routledge (2004).
8. *Guide to Quality Management Systems for the Food Industry* by R. Early, Blackie Academic, NY (1995).
9. *Intellectual Property Law* by Davis, Jennifer, Butterworth's, London (2001).
10. *Intellectual Property Rights on Biotechnology* by K.C. Singh, BCIL, New Delhi (2004).
11. *Intellectual Property Rights: Patent Laws in India* by G.V. Rao, SSDN Publishers (2013).
12. *Intellectual Property Rights: Innovation, Governance and the Institutional Environment* by I. Andersen, Edward Elgar Publishers (2006).
13. *Intellectual Property: Patents, Trade Marks and Allied Rights* by W.R. Cornish, Universal Law Publishing, Delhi (2001).
14. ISO 14000:2004- BIS publication
15. ISO 9000:2008- BIS publication
16. *Law of Intellectual Property* by S.R. Myneni, Asia Law House, Hyderabad (2001).
17. *Patenting Lives: Life Patents, Culture and Development* by J. Gibso, Ashgate Publishers (2008).

Paper Code:	BTHM2105T - RESEARCH METHODOLOGY
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

The course will cover some basic concepts of research and its methodologies to identify appropriate research topics, and to select and define appropriate research problems and parameters. This course will also help to develop basic understanding about scientific writing skills, and ethics of scientific writing.



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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. **Fundamentals of biostatistics:** Statistical terminology, reliability and validity of data, quantitative and qualitative data.
2. **Data measurement:** Mean, median, mode, sampling techniques.
3. **Statistical analysis:** Probability, correlation and regression analysis.
4. **Statistical tools:** Student's T-test, analysis of variance (ANOVA) and chi-square test.
5. **Biosafety:** Introduction to EPA, 1986; Indian Scenario-IBSC guidelines for conduct of field trials regulated GE plants; Guidelines for generating preclinical and clinical data for DNA based vaccines, diagnostics and other biologicals, 1999.
6. **Good lab practices:** OECD guidelines; Role of DST - NGCMA; GILSP concept.

SECTION-B

7. **Scientific writing:** Types - monographs, review articles, research papers, thesis, books and technical reports; Techniques and importance of scientific writing.
8. **Experimental design:** Research hypothesis, Experimental design and research plan.
9. **Literature review:** Significance of literature review; Sources of scientific information; Organization of literature.
10. **Scientific presentation:** Layout and design of scientific documents - thesis, research paper, posters; Oral presentation.
11. **Scientific journals:** Types; Impact factors of journals; h-index, i10 index; Predatory journals and publishers.
12. **Ethics:** Ethical issues related to publishing; Plagiarism; Authorship issues.

RECOMMENDED READINGS

1. *Statistics – An Introductory Analysis* by Taro Yamane, Harper International Edition (1994)
2. *Biostatistics* by B Williams, Chapman & Hall Publ., London (1993).
3. *An Introduction to Statistical Methods* by C.B. Gupta, Vikas Publ. Co., Jalandhar (1997).
4. *Statistical Methods in Biological Assays* by D.J. Finney, Charles Griffins & Co., London (1964).
5. *Biostatistics the bare essential*, (Decker Inc. 2008) by Norman & Streuer
6. *Biostatistics*, Veer Bala Rastogi. (Medtec Publishers), 3rd edn. (2015)
7. *Research Methodology: Methods and Techniques* by CR Kothari and Gaurav Garg by NewAge International Publishers (Third Edition), ISBN-10:8122436235, ISBN-13:978-8122436235
8. *Research Methodology: A step-by-step Guide for Beginners* by Ranjit Kumar, SAGE Publications, ISBN-13: 978-1849203012
9. *Research Methodology for Life Sciences* by Dr. N. Arumugam by Saras Publication, 2015, ISBN-13 -978-9384826796
10. *Research Methodology in the Medical and Biological Sciences* by Petter Laake, Haakon Benestad, Bjorn Olsen by Elsevier Publications, 2017 (First Edition). Paperback ISBN - 97801233738745, eBook ISBN: 9780080552897

Paper Code:	BTHM2101L - PRACTICAL PAPER - V Pertaining to theory papers BTHM2101T & BTHM2102T	
Max. Marks: 100		Total practical hours: 60
Credits: 3		Time: 4 hours
		Pass Marks 40

BTHM2101T: Enzymology & Enzyme Technology

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, proteases, etc.

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

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.

BTHM2102T: Food Biotechnology

1. Enzymatic preparation of high fructose syrup and maltose syrup.
2. Utilization of fermentation industry waste.
3. Preparation of Indian fermented foods.
4. Production of lactic acid fermented food.
5. Preparation of fermented dairy products.
6. Biopreservation of food.
7. Extraction of microbial pigments.
8. Production of baker's yeast and evaluation of its leavening effect.
9. Production of fructooligosaccharides.
10. Fermentative production of organic acids.
11. Production of various types of wines using free and immobilized cells.
12. Production and evaluation of single cell protein-fungal and yeast biomass.
13. Production of bread using baker's yeast.
14. Evaluation of probiotic characteristics of lactic acid bacteria.
15. Ethanol production from whey.
16. To check the presence of adulterants in the given food sample

Paper Code:	BTHM2102L - PRACTICAL PAPER - VI
	Pertaining to theory papers BTHM2103T & BTHM2104T/BTHM2105T
Max. Marks: 100	Total practical hours: 60
Credits: 3	Time: 4 hours
	Pass Marks: 40

BTHM2103T: Advances in Environmental Biotechnology

1. Adulteration check in milk by Urea Biosensor
2. Biogas production monitoring by gas chromatography.
3. Bioremediation of heavy metal ions
4. Bioremediation of heavy metal laden (Ni^{+2}) industrial effluent by immobilized cyanobacteria through packed bed reactor.
5. Bioremediation of pesticides.
6. Bioresin for treatment of chromium-laden effluents.
7. Calibration of DO Probe.
8. Calibration of ISE Electrode.
9. Characterization of industrial effluents for pH, TS, TDS, TSS, acidity, alkalinity and hardness parameters.
10. Co-Immobilization of enzyme and indicator dye for construction of Biosensor.
11. Demonstration of biogas production from industrial effluents using batch and anaerobic baffled reactors.
12. Demonstration of vermicompost and landfill technologies.
13. Detection of pesticides by HPLC method.
14. Determination of chemical oxygen demand (COD) in various effluents.
15. Determination of chromium content in a given industrial sample.
16. Determination of heavy metal ions in industrial effluents by Atomic absorption spectrophotometer and spectrophotometric methods.
17. Development of heavy metal ions in industrial effluents by spectrophotometric method.
18. Development of biosensor (enzyme based/ microbe based) for monitoring heavy metal ions in the environment.
19. Development of biosensor (enzyme based/ microbe based) for monitoring pesticides in the environment.
20. Development of BOD Biosensor
21. Development of Urea Biosensor
22. Evaluation of Biochemical Oxygen Demand (BOD) in various effluents.
23. Heavy metal decontamination of effluents by microbial systems.
24. Isolation of microbial consortia from fermentation industry.
25. Microbial degradation of heavy metal ions by free cell and immobilized systems.

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

26. Microbial degradation of pesticides.
27. Microbial degradation of textile dyes by free cell and immobilized systems.
28. Microbial degradation of xenobiotics.
29. Microbiological analysis of waste water.
30. Production of bioalcohol from agricultural, dairy and food waste.

BTHM2104T: Intellectual Property Rights, Biosafety & Entrepreneurship

1. To demonstrate the development of a small-scale vermicomposting bin for commercialization
2. Overview of IP office websites: India, USA.
3. Overview of patent databases.
4. National patent search: Indian patents
5. International patent search on US patents and EPO patents.
6. Overview of ISO's official website
7. Study of implementation of ISO standards in a concern
8. An over view of ISO 9000 family of quality management standards.
9. A brief about ISO 9000 certified Indian companies
10. An overview of ISO 14000 family of environment management standards.
11. A brief about ISO 14000 certified Indian companies.
12. A brief about ISO 22000 certified Indian companies.
13. Overview of biotechnology industries in Punjab.
14. Overview of biotechnology industries in India.
15. Use of MS-Office software to sketch a company profile.
16. To identify the TQM related problems in an organization and to give a possible solution.
17. To study the essential elements of TQM.
18. Internet Survey of Biotechnology Industries Globally.
19. Internet Survey of Biotechnology Industries of India
20. Data retrieval from IGMORIS site pertaining to Genetically Modified LMOs.
21. Designs of Biosafety Lab Level I,II, III and IV.
22. Internet Survey of BIO, FDA and WHO pertaining to GMOs.

BTHM2105T: Research Methodology

1. Data analysis using MS-Excel
2. To perform Student t-test
3. To perform Correlation analysis
4. To perform Regression analysis
5. To perform ANOVA analysis
6. To create Power point Presentation
7. Plagiarism testing (Central Library, Punjabi University, Patiala)
8. How to search journals of interest
9. Impact factor of journals
10. Quoting scientific literature - reference or bibliographic writing
11. Sources of information - Scientific literature databases
12. Write the protocol prescribed by DBT for Biosafety clearance of vaccines
13. Make a list of Biosimilars
14. Write the DBT protocol for Biosafety clearance of Biosimilars



SEMESTER-IV

Paper Code:	BTHM2201T - ANIMAL AND PLANT TISSUE CULTURE TECHNOLOGY
Max. Marks: 74	Lectures to be delivered: 60
Credits: 5	Pass Marks: 40%
Time allowed: 3 Hours	(Theory and Practical separately)

OBJECTIVES

For animal cell and tissue culture: The students get an in depth knowledge about growing the animal cells *in vitro* to get cell mass, tissues, and their applicability example in managing cancer, transplantation tissue, stem cells and IVF and super ovulation.

For plant cell and tissue culture: The objective of this is to learn the mass propagate the plants *in vitro* and how to raise virus free, pest resistance, new variety of plants etc. keeping in view the applicability of PTC.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. **Plant tissue culture:** Introduction and history, scope and applications, culture room and vessels, medium constitution and functions of each element, growth regulators, sterilization techniques; Setting up of primary culture.
2. **Callus:** Formation, cloning, suspension culture, regeneration.
3. **Somatic embryogenesis:** Factors and molecular aspects; Micropropagation; Raising of virus free and pest resistant plants, methods.
4. **Germplasm conservation:** Cryopreservation methods, slow growth, applications and limitations.
5. **Haploid production:** Androgenesis, gynogenesis, embryo rescue, somatic hybridization, proroplast isolation, fusion and selection of hybrids; Application; Cybrids formation.
6. Somaclonal variation, plant transformation techniques; Secondary metabolites.

SECTION-B

7. **Animal cell culture:** Historical background, scope, biology of cultured cell, media composition, preparation, sterilization techniques for ATC lab and maintenance of contamination free conditions.
8. **Animal cell lines:** Types of cell lines (Monolayer and suspension cultures); Setting up of primary culture - Disaggregation methods and cell line kinetics, properties; Maintenance of cell line - subculture, viability testing, treatment of substratum, feeder layers.
9. **Scale up of monolayer and suspension cultures:** Scale up of monolayer culture - NUNC cell factories, multi array disk, roller culture, perfused monolayer culture; Scale up of suspension cultures - stirrer or spinner culture; Bioreactors – wave bioreactor, biostat, rotating chambers, airlift fermenter, fluidized bed reactor, hollow fiber, perfused, NASA bioreactor; Differentiation inducers, characterization of cell lines.
10. **Somatic cell fusion:** Monoclonal antibody formation, culture of tumor cells; Cloning of cultured cells – methods.
11. **Animal cloning:** Superovulation, embryogenesis, *in vitro* fertilization; Stem cells technology: Culture, characteristics.
12. **Applications:** Industrial applications of ATC; Stem cell applications; Mammalian cell products applications – monoclonal antibodies, vaccines, therapeutic, recombinant glycoproteins from mammalian cells, tissue engineering, cells as products.

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, Buchingham (1988).
3. *Animal Cell Culture Technology* by M. Buttler, Open University Press, Buchingham (1987).

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

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. *Principles of Plant Biotechnology* by H. Maitel I, J. Mathew and R.A. Mackee, Blackwell Scientific Publishers, Oxford (1985).
10. *Plant Cell Culture Technology* by M.M. Yoeman, Blackwell Scientific Publication, Oxford (1986).
11. *Plant Cell Culture* by A. Stanford and G. Warren, Open University Press, Buchingham (1990).
12. *Plant Cell and Tissue Culture A Laboratory Manual* by J. Reinart and M.M. Yoeman, Narosa Publishing House, New Delhi (1982).

Paper Code:	BTHM2202T - COMPUTATIONAL BIOLOGY AND APPLIED BIOINFORMATICS	
Max. Marks: 74		Lectures to be delivered: 60
Credits: 5		Pass Marks: 40%
Time allowed: 3 Hours		(Theory and Practical separately)

OBJECTIVES

The Computational Biology and Applied is designed to give a strong competence in the field of bioinformatics and computational biology. The subject is designed to provide robust background knowledge in machine learning, *in silico* modelling and data analysis to understand biological properties of cellular macromolecules. The subject offers several statistical models and mathematical expressions to understand, gather and disseminate information captured in biological and macromolecular interaction databases. To ensure better understanding of both theory and practice of the methods, hands on training is imparted in the form of specially designed practicals. Examples of research questions studied include modelling 3D structures of proteins, predicting functional and evolutionary relationships of biological sequences, and reconstructing biological networks by analysing properties of the complex biological pathways.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION – A

1. **Bioinformatics and computational biology:** Definition, applications in scientific research, present bioinformatics scenario in India; Open access computational and bibliographic resources related to Life Sciences viz., NCBI, EXPASY, PubMed Central.
2. **Nucleotide sequence databases:** Characteristics and categories of biological databases, navigating databases; Organization of databases - data contents and formats of data entries, purpose and utility in life sciences, the knowledge of various computational tools available at these resources - INSDC, Genbank, EMBL, DDBJ.
3. **Protein sequence, structure and interaction databases:** Characteristics and categories of biological databases, navigating databases; Organization of databases - data contents and formats of data entries, purpose and utility in life sciences, the knowledge of various computational tools available at these resources: protein sequence databases - Swiss-Prot; Protein structure databases - PDB; Protein structure classification databases - CATH, SCOP; Protein family classification - Pfam; Protein-protein interaction database - STRING.
4. **Specialized and composite databases:** Composition, organization and format of data entry; Diseases database (OMIM), metabolic pathways (KEGG); Composite databases: BIOSILICO; Microbial genome databases with special reference to model organisms (*E. coli*, Yeast).

5. **Information retrieval and data submission systems:** Keyword-based and advanced searches using tools like ENTREZ; Sequence submission using BankIt, Sequin, WebIn, Spin (Swiss-Prot).
6. **Substitution matrices algorithms for scoring sequence alignments:** PAM matrix construction algorithm, BLOSUM matrix construction algorithm; Nucleic acid substitution matrices; Use of gaps and gap penalties.

SECTION – B

7. **Algorithms of sequence comparison:** Definition, dynamic programming; dot plots; sequence comparison algorithms: Pairwise comparison, global sequence alignment algorithm (Needleman Wunsch algorithm), local sequence alignment algorithm (Smith Waterman algorithm), semi-global algorithm.
8. **Pairwise sequence alignment:** Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues; Types and applications of BLAST and FASTA, statistical significance of scores; Nucleic acid sequence analysis - pairwise alignment, ORF and restriction analysis, sequence translation; Protein sequence analysis - pairwise alignment, peptide cleavage analysis, prediction of transmembrane proteins, *in silico* analysis of protein modifications, reverse translation.
9. **Genome analysis using pairwise sequence alignment:** Overview of web resources for genome information and analysis; Gene identification methods (GENSCAN, GLIMMER).
10. **Multiple sequence alignment and phylogenetic analysis:** Multiple sequence alignment tools - clustalW, its application for sequence analysis (including interpretation of results); Relationship of phylogenetic analysis and sequence alignment, overview of phylogenetic analysis methods; Distance scores; Tree confidence; Analysis tools - Phylip, Phym1.
11. **Prediction of protein secondary structure:** Chow-Fasman/GOR method, secondary structure prediction by Neural Network (NNSSP), analysis of results and measuring the accuracy of predictions; Viewing protein structures and 2D modeling: RASMOL, CHIME.
12. **Prediction of protein 3D structure:** Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding, etc.), homology/comparative modeling, fold recognition, threading approaches, and ab initio structure prediction methods; 3D modeling: DeepView (SwissPDB viewer).

RECOMMENDED READINGS

1. *Bioinformatics: Sequence and Genome Analysis* by D.W Mount, Cold Spring Harbor Press, NY (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, UK (2000).
4. *Introduction to Bioinformatics* by A.M. Lesk, Oxford University Press, UK (2005).
5. *Practical Bioinformatics* by J.M. Bujnieki, Springer-Verlag Berlin, Heidelberg (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, UK (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*, (volume 132; *Bioinformatics: Methods and Protocols*) by S. Misener and S.A. Krawetz, Humana Press Inc. (2000).
14. *Bioinformatics: Databases, Tools and Algorithms* by O. Bosu and S.K. Thukral, Oxford University Press, UK (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).

PUP_M.Sc. (Hons.) Biotechnology Part 2 (Semester III & IV)

Paper Code:	BTHM2201L - PRACTICAL PAPER - VII Pertaining to theory papers BTHM2201T & BTHM2202T
<i>Max. Marks: 100</i> <i>Credits: 3</i>	<i>Total practical hours: 60</i> <i>Time: 4 hours</i> <i>Pass Marks 40</i>

BTHM2201T: Animal & Plant Tissue Culture Technology

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.

BTHM2202T: Computational Biology & Applied Bioinformatics

1. Open access computational and bibliographic resources related to Life Sciences viz. NCBI, EBI, EXPASY, EMBOSS, PubMed Central
2. Keyword-based and advanced searches using tools like ENTREZ and SRS
3. Formats, querying and retrieval from GenBank, EMBL, DDBJ
4. Formats, querying and retrieval from Swiss-Prot, TrEMBL, PIR-PSD, UniProt-KB; PDB; CATH, SCOP, Pfam, PROSITE; STRING
5. Formats, querying and retrieval from OMIM, KEGG, BRENDA; OWL, BIOSILICO
6. Genomes of model organisms (Yeast, *E. coli*)
7. Types and applications of BLAST
8. Types and applications of FASTA
9. Nucleic acid sequence analysis: pairwise alignment, ORF and restriction analysis, sequence translation, gene prediction using GENSCAN, GRAIL
10. Protein sequence analysis: pairwise alignment, peptide cleavage analysis, prediction of transmembrane proteins, *in silico* analysis of protein modifications, reverse translation
11. Viewing protein structures and 2D modeling: RASMOL, CHIME
12. Protein 3D structure prediction
13. Phylogenetic analysis: Phylip, Phylml

Paper Code:	BTHM2203T - OPEN ELECTIVE SUBJECT - BASICS OF BIOTECHNOLOGY
<i>Max. Marks: 74</i> <i>Credits: 5</i> <i>Time allowed: 3 Hours</i>	<i>Lectures to be delivered: 60</i> <i>Pass Marks: 40%</i> <i>(Theory and Practical separately)</i>

OBJECTIVES

Basics of Biotechnology describes introduction to history, scope, importance and interdisciplinary nature of biotechnology and its impact on society. The application of biotechnology in agriculture, environment and pharmaceutical sector is highlighted. The legal and socioeconomic impact of biotechnology on society would also be deliberated.

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 11 marks each. Section-C consists of 15 short answer type questions which will cover the entire syllabus uniformly and will carry 30 marks in all.

14

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION - A

1. **Biotechnology:** Origin and definition; Biotechnology for welfare of mankind.
2. **Biomolecules:** Introduction to carbohydrates, proteins, nucleic acids and lipids.
3. **Immune system:** Immunity, Immunization and Vaccines, Monoclonal antibodies.
4. **Microbes:** Growth and control, beneficial and harmful microbes, normal microflora associated with human and animals, Microbes in human and animal nutrition and health, Plant microbe interactions and benefits.
5. **Genetics and Genetic engineering:** Basics and applications.
6. **Biotechnology in Food Industry:** Concept and applications.

SECTION - B

7. **Biotechnology in Agricultural sector:** Concept and applications.
8. **Biotechnology in Environment:** Concept and applications.
9. **Biotechnology in Medicines:** Concept and applications.
10. **Intellectual Property Rights in Biotechnology:** Concept of Intellectual property (IP), Intellectual Property Rights (IPRs) in India, Patenting system in India, Scope of Protection of IP in Biotechnology.
11. **Biosafety:** Objectives, risk assessment of GMOs, hazardous waste used in biotechnology, handling and disposal.
12. **Bioethics:** Animal cloning and ethical issues, public education transgenic organisms, legal and socioeconomic impacts of biotechnology, testing drugs on human volunteers

RECOMMENDED READINGS

1. *Biochemistry* by L. Stryer, W.H. Freeman and Company, New York (2002).
2. *Lehninger Principles of Biochemistry* by D.L. Nelson and M.M. Cox, Macmillan worth Publisher, New York, USA (2012).
3. *Microbial Genetics*; by D. Friefelder, Narosa Publishing House, New Delhi, 1989.
4. *Molecular Biology*; by D. Friefelder, Narosa Publishing House, New Delhi, 1998.
5. *Molecular Biology and Human Diseases*; by A Macleod and S. Sijkora, Blackwell Scientific Publications Ltd., London, 1984.
6. *General Microbiology* by R.Y. Stanier, J.L. Ingraham, M.L. Wheelis and P.R. Painter, Mac Millan, Hong Kong (2005).
7. *Microbiology: A Human Perspective* by E.W. Nester, D. Anderson, Jr. Roberts and C. Evans, Mc Graw-Hill Education, India (2011).
8. *Microbiology: An Introduction* by G.J. Tortora, Pearson Education, India (2008).
9. *Fundamental Immunology* by W.E. Paul, Lippincott Williams & Wilkins, USA (2008).
10. *Immunology: An Introduction* by I.R. Tizard, Saunders College Publishing, Philadelphia (1995).
11. *Kuby Immunology* by J. Owen, J. Punt and S. Stranford, W.H. Freeman and Co., USA (2012).
12. *Manual of Industrial Microbiology and Biotechnology*, R.H. Baltz, Julian E. Davies and Arnold L. Demain, ASM Press, USA (2010).
13. *Prescott and Dunn's Industrial Microbiology* by G. Reed, CBS Publishers and Distributors, India (2004).
14. *Food Microbiology* by M.P. Doyle and L.R. Beuchat, ASM Press, USA (2007).
15. *Food Microbiology* by W.C. Frazier and D.C. Westhoff, Tata McGraw-Hill Publication, India (2003).
16. *Food Biotechnology: Principles and Practices* by V.K. Joshi and R.S. Singh, IK International Publishers Pvt. Ltd., New Delhi (2012).
17. *Food Fermentation Biotechnology* by A.K. Pandey, C.R. Soccol and C. Larroche, Asiatech Publishers Inc., New Delhi (2011).
18. *Environmental Biotechnology, Basic concepts and Application* by I.S. Thakur (2006).
19. *Environmental Engineering* by H.S. Peavy, D.R. Rowe and G. Tchobanoglous, Mc Graw Hill International Edition (1988).
20. *Intellectual Property Rights on Biotechnology* by K.C. Singh, BCIL, New Delhi (2004).
21. *Intellectual Property Rights: Innovation, Governance and the Institutional Environment* by I. Andersen, Edward Elgar Publishers (2006).

③